GENETIC ANALYSIS OF OIL CONTENT AND SOME AGRONOMIC TRAITS IN MAIZE (*Zea mays* L.)

By

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DECLARATION

I hereby declare that the work in this thesis titled "Genetic analysis of oil content and some agronomic traits in maize" was carried out by me in the Department of Plant Science, Faculty of Agriculture Ahmadu Bello University, Zaria, under the supervision of Prof. S.G. Ado, Prof. M. Yeye and Dr. I.S. Usman. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this work has been presented for another degree or diploma at any institution.

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CERTIFICATION

This thesis titled "Genetic analysis of oil content and some agronomic traits in maize" meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University Zaria, and is approved for its contribution to knowledge and literacy presentation.

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DEDICATION

This work is dedicated to the Almighty God, my parents and my beloved family.

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ABSTRACT

The aim of this study was to determine the mode of gene action that controls percent oil, to estimate correlation coefficient between oil content with agronomic traits, to determine direct and indirect relationships between oil and agronomic traits and to estimate heterosis for oil content. Sweet corn white and sweet corn yellow were used as high oil male parents, which were crossed to ten low oil maize varieties (Oba Super 2, SDM2, Sammaz 13, Sammaz 36, Sammaz 29, Sammaz 27, Sammaz 20, Ex Yola Dt, Sammaz 18 and Sammaz 37). North Carolina Design II mating design was used to develop progenies. Evaluation was carried out at two locations, Samaru and Kadawa. Result for males and females sources of variation for Samaru indicated no significant differences for percent oil while male x female sources of variation indicated significant difference for percent oil. Result for Kadawa indicated that males, females and males x females' source of variation were not significant for oil content. For the combined locations, males, females and males x females' source of variation indicated no significant differences for percent oil. The males x location, females x location and males x females x location sources of variation indicated no significant difference for percent oil. Broad sense heritability for oil content at Kadawa indicated low estimate of 0.3214, which indicates possibility of low genetic advance. Narrow sense heritability estimates was high at Samare but for Kadawa and across locations the estimates were low for oil content. Negative mid and high parent heterosis was observed for oil content at both and for across locations, this indicated that the genes for oil content are not contributing positively for oil content. Results at Samaru indicated no significant genotypic and phenotypic correlations between

oil content with all the traits, but results for Kadawa indicated significant genotypic correlations between oil content with number of kernel rows and significant phenotypic correlations between oil content with ear height, number of leaves per plant and number of kernel rows. For the combined locations, positive significant phenotypic correlation between oil content with number of kernels rows was observed. Path analysis result for Samaru indicated that plant height had positive significant direct effect to oil content. From Kadawa the result indicated 100 grain weight, ear height, and numbers of kernel rows exert positive direct effects toward oil content. For combined locations, grain yield indicated positive direct effect toward oil content. From this results the most suitable breeding methodology for breeding high oil Maize are recurrent selection or use of inbred lines, because heterosis is easily obtained from inbred lines crosses.

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CHAPTER 1

INTRODUCTION

1.1 Origin of Maize

Maize (*Zea mays* L.) originated from Mexico; and it was introduced to Africa in the 6th century, most likely by the Portuguese. Maize is a temperate season crop, but breeders have developed varieties that can be grown in almost any climate. Maize requires an average temperature of about 24 ^{0}C during the day and 14 ^{0}C in the night. Rainfall should be well spread (about 460 - 600mm) during the growing period (Miracle, 1966). Before the introduction of maize, millet and sorghum were the major cereal crops grown in West and Central Africa. The dramatic expansion of maize production started from 1970 onward (Smith *et al.,* 1994). The total land area under cultivation has increased in Nigeria especially in the savannah, while the yield per unit area is still very low, with less than 2t/ha as opposed to on station yield of about 6t/ha in the region (Fakorede *et al.,* 2005). In Africa, maize is complementing traditional starchy food stuffs such as millet and sorghum (Miracle, 1966). Maize is the third most important cereal crop in the world after rice and wheat. About half of world maize production is in the developing countries, where maize flour is the staple food for poor people. According to Food and Agriculture Organization of the United Nations, United States of America is the largest producer of maize with an annual production of 187,698,992 tones, while Nigeria is the twelfth largest producer, with an annual production of 6,931,000 tones (GeoHive, 2002). Maize production currently averaged 1.5t/ha in Africa, slightly above 3t/ha in Latin America and 1.7t/ha in Asia. Maize is a short duration crop in the tropics with possibility of raising two crops a year. If given proper agronomic management, it will surpass any other cereal

crop in yield. Maize has been closely linked with economic development of tropical Africa more than any other starchy staple food in a number of countries including Nigeria. Maize is grown for many reasons including its use as food and industrial applications. In Africa, including Nigeria, it is used primarily as a source of food, while in developed countries like the United States of America and Europe about 90% of the crop is fed to livestock (Jugenheimer, 1975). Corn Industrial Research Foundation of the United States of America (C.I.R.F, 1952) listed more than 500 important products and bye products of corn and their uses. The uses are divided among the three consuming groups, the livestock, industries and humans. For livestock, it may be directly feeding the animals with grains, the stalk for silage making, grazing and for forage making. The industrial uses include starch, animal feeds, syrup, oil and dextrin and for human consumption it is used for corn meal, corn grit, and corn oil.

1.2 High Oil Maize Production and Uses in Some Countries of the World

United States of America (U.S.A. Patent, 2004) reported that maize oil can easily be extracted on commercial scale from conventional corn grain, that is, the kernel is separated into its components, the endosperm, germ and the pericarp, and then the oil is extracted from the corn germ. As a result of this, the United States of America has developed various methods for extracting corn oil from the conventional corn separates, U.S.A. Patent. (2004). About 500,000 hectares of high oil corn were grown in the U.S.A. of which about 65% of these areas were grown under contract for export, while the remaining 35% was grown for domestic consumption, U.S.A. High oil updated. (2003). In Pakistan, a team of breeders in the University of Faisalabad has developed new

methods of extracting oil from maize kernel, of which the country can save substantial amount of foreign exchange, which is spent on import of edible oil (Naz, 1989). Also in Pakistan, it was reported that there was an international demand for quality parameters in maize crop such as high oil, high protein etc. In order for the country to have access to international market, there was need to improve the quality of their maize crop for parameters like the oil (Saleem *et al.,* 2008). In China, the production of maize oil exceeded 400,000 tones, the majority of which is for industrial uses, for soap making, etc. Chinese maize oil production increased at a rate of over 30%. In 2007, consumption of edible maize oil was only 80,000 tones, in 2008 the consumption reached 120,000 tones; the consumption is predicted to reach 160,000 tones in the developed region of China. The maize oil is expected to be a new highlight of the edible oil market which is influenced by health consumption concept (C.R.I., 2010). In 2008, the global consumption of maize oil was reduced considerably compared with that in 2007, because of global economic crises.

1.3 Justification

Maize crop plays an important role in the world economy and it is the available ingredient in manufactured of items that are used by a proportion of world population (Alvi *et al.,* 2003).Maize is the most widely grown cereal in the world after wheat and rice (Haq *et al.,* 2005). In Nigeria Maize crop is largely being grown for human consumption and livestock feed ingredient, Maize crop is presently complementing our starchy food crops such as Millet and Sorghum. The main aim of any breeding programme is to obtain a new variety that will out perform the existing varieties especially with respect to yield. Besides that attention should be paid only to grain yield,

other important grain quality should be considered such as oil content (Laurie *et al.,* 2004). International demand for quality parameters such as oil and protein is increasing (Saleem *et al.,* 2008). Oil production from maize has been increasing rapidly (Dudley and Lambert, 1992). Maize oil is a very valuable bye product of starch industry and is a high energy value for livestock feed ingredient. The use of high oil maize is not only to improve feed conversion, but also it reduces the amount of fat needed in the livestock feeds (Goldman *et al*., 1994). Oil from maize can also be used in bakery products, cooking oil, oleo margarine, and salad dressing as well as in pharmaceuticals. Maize oil is assimilated as quickly as possible as carbohydrate and protein, and it can provide energy over an extended period of time. Certain unsaturated fatty acids in the oil of maize are essential for growth, pregnancy and lactation. Maize oil which contains high amount of unsaturated fatty acids reduces the hazard of accumulation of lipid or fat in the arteries (Jugenheimer, 1961). The maize oil, because of its level of saturated fatty acid content and high level of polyunsaturated fatty acids, fetches premium prices among the health conscious people (Naz, 1989). The unsaturated fatty acids can also soften blood vessels, enhance cardiovascular system function, prevent and improve arteriosclerosis. Beside linoleic acid, maize oil is also rich in sitosterol and vitamin E. The sitosterol can reduce the cholesterol and lower initiation potential of angiocardiopathy, while vitamin E is natural antioxidant which can defer senescence of human body. The maize oil is absorbed by the human body; the absorption is as high as 97% (C.R.I., 2010). The non food uses of refined maize oil include ammunition, paint, varnish, rubber substitute, rust preventive, soap oil and in textile making (Jugenheimer, 1961). Maize breeders suspected that oil content is negatively correlated with yield. (Obi, 1991) pointed out that it is not possible

to combine oil content with high yield in cereals, this is probably because of reduction in starch content in the grain. How ever several researchers have paved way toward simultaneous selection of high quality such as oil and high yielding varieties (Rajini Raman *et al.,* 1983) found out that oil content is positively and significantly correlated with 100 kernel weight, plant height, ear height and grain yield. Therefore, there would be no serious barrier in selecting for both high yields with high oil content. In Nigeria little research work has been reported on maize oil. It is therefore very important to put effort toward development of maize with high oil content.

1. 4 Objectives

1. To determine the variability for oil content among the progenies developed.
2. To determine the mode of gene action that is involved in the inheritance of oil content in maize.
3. To determine the direct and indirect contributions of agronomic characters toward oil content.
4. To recommend suitable breeding methods for improvement of oil content in maize.

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CHAPTER 2

LITERATURE REVIEW

2.1 Breeding for High Oil Content Maize

Oil content in maize kernel is almost entirely under genetic control but also it is influenced by external factors such as season, soil fertility, etc. Evidence for such control is the response of oil content to various selection methods (Sprague and Brimhall, 1949). Woodworth *et al*. (1952) reported that oil content in maize variety of Burr white was increased from 4.7% to about 15% in 50 generations of mass selection programme. Sprague *et al.* (1952) increased oil content of a maize variety from 4.2% to7.0% by two cycles of recurrent selection programme. Alexander (1962) demonstrated the effectiveness of recurrent selection by increasing oil content from 4.4% to 6.3% during three cycles in a synthetic variety composed of many open pollinated varieties. Jugenheimer (1961) increased oil content in a back crossing programme involving standard inbred and Illinois high oil as a non recurrent parent. The inheritance of oil content is an independent characteristic (Curtis *et al.,* 1968). (Rosulj *et al.*, 2003) increases oil content in a maize population of Ds7u, after nine cycles of mass selection, the oil content was increased from 4.46% - 16.1%. Alexander and Lambert (1968) reported that about 20-40 genes are involved in the determination of oil content in maize kernel and these genes exhibit incomplete dominance (Sprague and Brimhall, 1949). Many investigators have studied the genetics of oil content in maize, but no mutant that substantially influences oil content has been isolated.

2.2 Variability for Oil Content in Maize Germplasm Materials

Variability for each major nutrient component in maize is great i.e., the oil, protein and starch. Concentration of oil content in maize exhibits wide variation from 0.5% to as much as 18-20%. Since great variation exists, it seems that appropriate breeding programme should produce hybrids with oil content above 4.0- 4.5 % (Walden, 1932). Saleem *et al.* (2008) evaluated 10 maize genotypes for fatty acids detected from the grain oil and the result showed significant variability among the genotypes tested. Copandean *et al.,* (2009) examined grain variability for oil, starch and ash content among 754 maize samples. The oil and ash content showed high variability among the genotypes tested. Oliveira *et al*. (2006) studied quality protein maize parent populations and their hybrids for oil content, the result indicated mean values of 5.04g $100g^{-1,}$ 4.78g $100g^{-1}$ and 6.84g $100g^{-1}$ for parent one, parent two and their progenies respectively this is indicating genetic variability for oil content.

2.3 Estimation of Variance Components for Mating Designs

Maize cultivars often have low oil content. To increase the oil content, efficient maize breeding programmes has to be developed, which require knowledge of inheritance of the trait (Mangolin *et al.,* 2005). Betrim and Hallauer (1996) used design II to produce half and full sib families in three hybrid maize populations, S1 families were evaluated in a replicated within set, randomized incomplete block design with two replications at five locations. The objectives were to estimate variance components, heritability, genetic correlation and genetic gain for the three hybrid populations. The result indicated that additive genetic variance component was the most important component in all the traits studied. Masoud and Saleem (2009) estimated gene actions for various quantitative and

qualitative traits using complete set of diallel involving seven elite inbred lines of maize. The results revealed that yield traits were controlled by over dominance type of gene action, while traits like oil and protein were controlled by partial dominance with additive type of gene action. Moreno-Gonzalez *et al.* (1975) estimated additive and dominance genetic variance and average degree of dominance for percent oil in maize from a cross of Illinois high oil and Illinois low oil, using design III. The result indicated that the additive genetic variance was about eight times larger than that of dominance in F_2 and about four times larger in the $F_{6.}$ Miller *et al.* (1981) estimated genetic variance components for percent oil and 100 grain weight using seven cycles of high intensity selection within half sib family of maize. All estimates of additive variance were greater than zero; however, no change in additive variance occurred between cycles. Estimates of dominance genetic variance did not differ from zero.

2.4 Heritability Estimates

Heritability expresses the total variance that is attributed to the total effect of genes, and this determines the degree of resemblance between relatives Falconer. (1960). Narrow sense heritability is the fraction of additive genetic variance to the total phenotypic variance, and it should normally lie between 0-1(Prabhakaran and Jain, 1987). Rafiq *et al.* (2010) crossed ten local maize inbred lines to three testers, to study heritability of traits affecting maize grain yield. The result revealed that, most traits had high narrow sense heritability estimates, which is indicating preponderance of additive gene action. Wannous *et al.* (2010) produced hybrids using half diallel fashion to study narrow sense heritability. The obtained results indicated number of kernels per row, plant height, ear height, number of ears per row; ear length and ear diameter had high narrow

sense heritability estimates. Hallauer and Miranda (1981) reported that heritability in maize was distributed according to the following ranges: percent oil (h^2 > 70%), plant height, ear length, number of kernels per row and number of kernel rows (h^2 50-70%), while ear height and kernel weight (h^2 30 -50%).

2.5 Heterosis

Yusuf *et al.* (2009), conducted crosses of six quality protein maize inbred lines in a complete diallel and the thirty single cross hybrids were evaluated for heterosis. The result showed high level of both mid-parent and high-parent heterosis for grain yield and its components. Vasal *et al.* (1992) estimated heterosis and combining ability among CIMMYT's subtropical and temperate early maturing maize germplasm. A seven parent diallel involving two populations and five gene pools were made. From the results of subtropical environment, maximum high parent heterosis was observed in population 46 x Pool 30 (13%). Under temperate environment, maximum heterosis was observed between pool 27 x pools 40.

2.6 Correlation

Correlation studies simply measure the degree of association among important quantitative traits. Knowledge of interrelationships between traits improves the efficiency of breeding programmes through use of appropriate selection indices. If correlation is high, selection for one trait will simultaneously result in decrease or increase of the other trait. Haq *et al.* (2005) assessed thirty six maize hybrids along with their parent lines for 16 quantitative traits. The result revealed positive genetic correlation between grain yield and plant height, ear height, ear weight and kernel rows, indicating that selection for these characters can help to improve grain yield. The result also indicated that cob

diameter, 100 grain weight, ear length, kernel rows per ear and number of grains per row are significantly correlated with grain yield.

2.7 Path Coefficient Analysis

Path coefficient analysis permits the separation of correlation coefficients into direct and indirect effects. The direct effects are the direct causes between the causes and the effect, while the indirect effects are the interrelations between the causes themselves Modan *et al.* (2004).

Path coefficient analysis is divided into three components between the causes and the effect.

1. The direct effect of the causes toward the oil content.
2. The indirect effect of the causes toward the oil content (interrelationships between the causes)
3. The undefined factors.

Nemati *et al.* (2009) used path coefficient analysis to study relationship between some traits and yield components in maize. The result from the analysis revealed that, kernels per ear was the most important trait for selecting corn cultivars with high yield. Kernels per row and grain length had an effect on grain yield, thus these traits can be attended in breeding programmes and also be effective as potential traits in improving corn cultivars. Rafiq *et al.* (2010) determined the nature of interrelationship among traits affecting yield. The traits studied were ear diameter, ear height, 100 grain weight, number of kernel rows per ear, and number of grains per row. The result indicated that the traits with direct effects on grain yield were 100 grain weight followed by number of grains per row,

number of kernel rows per ear, ear length and ear diameter. Most of the traits exerted their effects through 100 grain weight.

2.8 Genotype by Environment Interaction

Genotype x environment interaction (G x E) is of notable importance in the development and evolution of a new variety. Genotype x environment interaction influences the progress of a breeder in his breeding programme mainly because the magnitude of such interaction varies with the materials tested and the sites chosen for testing. In general cultivars with small G x E interaction are usually more desirable. However, if cultivars are to be selected for specific locations, then cultivar development may be easier when large G x E interactions are present, since large G x E interactions indicated that varieties performance is location specific, such location specific varieties can then be released for adoption by farmers in those locations. Several statistical methods have been developed for the estimation of G x E interaction and regression analysis has been extensively used (Finlay and Wilkinson, 1963). Crop varieties differ genetically for their stability across different environments. An ideal variety is one that combines high yield with stability of performance. In other words, variation of genotype across locations is a measure of adaptability. The G x E interaction helps to identify which variety is best for what environment (Finlay and Wilkinson, 1963). Crops cultivated in a great variability of environment and knowledge on the performance of new lines brought forth by the breeders and the cultivars in use in different environments is determinant for success of a crop. Studies on adaptability and yield stability of cultivars and lines have pointed out the importance of interaction between genotype and environment and a consequence variable behavior of these genotypes according to different locations, years and cultivation

periods. The identification of strategic sites for the selection based on G X E interaction and using data on grain productivity and reaction to diseases is important. The success of any breeding programme on a diverse environment depends on: (i) Evaluation of the influence of year and location on yield (ii) identification of genotype with greater stability for yield on the diverse environments (iii) determining whether location belongs to a single mega-environment or a diverse set, and (iv) ranking locations based on discriminating ability and representativeness (Carbonel *et al.,* 2004).

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

List of varieties their sources and color were presented in Table 3.1

Table 3.1: List of varieties, their sources and grain color

No.	Variety	Source	Grain color
1	Sammaz36 (Cm 2007 Pool YQPM)	A. B.U. Zaria.	White
2	Sammaz18 (Tillering Maize)	A. B.U. Zaria.	White
3	EX YOLA DT	A. B.U. Zaria	White
4	Sammaz20 (TZE COMP 3 DT)	I. I. T. A Ibadan	White
5	Sammaz27 (EV 99 DT-WSTR)	I. I. T. A Ibadan	White
6	Sammaz29 (2000 SYN WSTR)	I. I. T. A Ibadan	White
7	Sammaz37 (POP66 SR)	I. I. T. A Ibadan	Yellow
8	Sweet corn Yellow	I. I. T. A Ibadan	Yellow
9	Sammaz13 (97 TZEE-Y)	I. I. T. A. Ibadan	White
10	Sweet corn White	I. I. T. A. Ibadan	White
11	SDM 2	Maslaha Seeds Company, Gusau	White
12	Oba Super 2	Premier Seeds Company, Zaria	Yellow

A. B. U. = Ahmadu Bello University. I. I.T.A. = International Institute for Tropical Agriculture.

3. 2 Methods

3. 2.1: Categorization of Working Materials Based on Oil Content

Oil analysis was carried out by the Product Development Research Programme of the Institute for Agricultural Research (I.A.R), Ahmadu Bello University Zaria Using (A.O.A.C.) method. The basis for carrying out the analysis was to have the prior knowledge on individual variety's oil content, so as to group them as parents based on the oil content.

Table 3.2: List of varieties and their oil content in percentages.

NO	VARIETIES	% OIL CONTENT
1	Sammaz36 (Cm 2007 Pool YQPM)	4.6
2	Sammaz18 (Tillering Maize)	3.1
3	EX YOLA DT	2.8
4	Sammaz20 (TZE COMP 3 DT)	4.8
5	Sammaz27 (EV 99 DT-WSTR)	2.9
6	Sammaz29 (2000 SYN WSTR)	3.7
7	Sammaz37 (POP66 SR)	3.8
8	Sweet corn Yellow	8.9
9	Sammaz13 (97 TZEE-Y)	5.5
10	Sweet corn White	9.6
11	SDM 2	3.4
12	Oba Super 2	4.2

3. 2. 2 Parents Grouping According to Lambert (2001), high oil maize has oil concentration in the grain that is greater than 6%. Based on Lambert's report, the

varieties were grouped into two sets, i.e. high and low oil varieties. Varieties with 6.5% and above as high oil, while the varieties with less than 6.5 % as low oil varieties. The two varieties that have high oil contents are sweet corn white and sweet corn yellow. All the remaining varieties have low oil contents.

3. 2. 3: Mating Design Used in the Experiment

Design II (Table 3.3) was used in carrying out the crosses between the different sets of parents that were classified into low and high oil parents. North Carolina design II is the most important in practical breeding programme for selection of test crosses performance. The design was chosen for this experiment because of the following reasons:

. Table 3.3: Design II mating design as used for the crosses:

	1 Sweet corn White	*2 Sweet corn Yellow*
3 Sammaz 13	*3x1*	*3x2*
4 Sammaz 18	*4x1*	*4x2*
5 Sammaz 20	*5x1*	*5x2*
6 Sammaz 27	*6x1*	*6x2*
7 Sammaz 29	*7x1*	*7x2*
8 Sammaz 36	*8x1*	*8x2*
9 Sammaz 37	*9x1*	*9x2*
10 SDM 2	*10x1*	*10x2*
11 Oba Super 2	*11x1*	*11x2*
12 Ex- Yola Dt	*12x1*	*12x2*

i) It can be used for pre-selection of inter-pool hybrids.

ii) It is used for estimation of general and specific combining abilities i.e. the mother plant is tested with a set of testers, the testers can be inbred lines, broad based testers or hybrids, the expected value of a cross with a specific male or female can be calculated.

iii) It can be used to predict the performance of three way cross hybrids.

iv) If data from homozygous parents is available, heterosis can be estimated in terms of mid-parent and high- parent (Comstock and Robinson, 1952).

v) It has the advantage of making two independent estimates of additive male and female variances and estimate of dominance can be determined directly from the mean squares.

vi) Large number of parents could be grouped into sets (Hallauer and Miranda, 1981).

3. 2. 4 Developments of Crosses

The parents were planted on June 6, 2010 at the Institute for Agricultural Research farm, Ahmadu Bello University Zaria. Staggered planting was done for both the males and the females in order to synchronize the tasseling and the silking dates to enable adequate crosses to be carried out. Herbicide (Gramoxone) was applied before -planting in the field at the rate of 1.5 kg ai/ha in order to control weeds. Ridges were made at 75cm apart. Planting was done with 3 seeds per at 25cm within row which were later thinned to one plant per stand. Each variety was planted on one row plot of five meters long and each male row was to one female. The planting pattern is illustrated below:

Fig 1: Layout of crossing parents



Fertilizer was applied three times as recommended at the rate of 120kg/ha of nitrogen, 60kg/ha of P_2O_5 and 30kg/ha of K_2O (Anon., 1989).

3. 2. 5: Evaluation of Entries

A total of 20 F_1 progenies were obtained. The progenies and their parents were evaluated in two locations, Zaria and Kadawa both in Institute for Agricultural Research (I.A.R) station farms, in a replicated experimental design using Randomized Complete Block Design. Ridges were constructed at 75cm apart. Planting was done on March 2, 2011 at Kadawa and March 7, 2011 at Zaria locations using 25cm within row spacing and one plant per stand in all the locations, irrigation water was used for the evaluation. Each of the parent varieties and their progenies were planted on one row plot of five meters long. A total of 32 entries were evaluated in each of the three replications. In both locations normal agronomic practices were carried out i.e. fertilizer was applied three times as recommended at the rate of 120kg/ha of nitrogen, 60kg/ha of P_2O_5 and 30kg/ha of K_2O (Anon., 1989).

3. 3 Data Collection

3. 3. 1 Morphological Data

The following data were taken in the field on the parents and their progenies. The data recorded were:

1. Plant height (PLHT): A measuring tape was used to measure the average of three plants in centimeters (cm) from the base of plant to where tassel branching begins.
2. Number of leaves (NOL): Average number of leaves per plant in each plot was recorded at maturity.
3. Ear height (EH): A measuring tape was used to measure the average height of three plants in centimeters from the base of plant to the node bearing the upper ear (cm).
4. Ear length (EL): A measuring tape was used to measure the average length of three cobs per plot and it was recorded in centimeters (cm).

3. 3. 2 Yield Data

1. 100 grain weight (100GW): the weight of 100 grains was recorded from three samples taken randomly and the average recorded in grams (g).
2. Number of kernel rows per ear (NKR): Number of kernel rows from three random cobs was counted and the average recorded.
3. Number of kernels per row (NK/R): Number of kernels per row was counted on all the rows from three randomly selected cobs, and the average was recorded.

.

4. Grain yield in (kg): Weighing balance was used to measure yield per plot which was converted to yield per hectare.

3. 3. 3 Oil Analyses Data

The oil content was determined following the procedure described in A.O.A.C (1980). A clean round bottom flask containing antidumping granules was used. About 210cm^3 of petroleum ether (60 – 80 ^{o} C) was poured into the flask fitted with soxhlet extraction unit. A weighed sample of 100g granules was transferred into a thimble which was already fixed into the soxhlet extraction unit. Cold circulation water was put on, then heating mantle was switched on and heating rate adjusted until the solvent was refluxing at a rate. Extraction was carried out for eight hours, the sample was removed and dried to a constant weight in an oven and the sample was reweighed. The oil content was obtained as:

$$\% \text{ lipid w/w} = \frac{\text{Weight of lipid extracted x100}}{\text{Weight of dry sample}}$$

w/w = weight to weight basis

The weight of lipid was given by the loss in weight of the sample after extraction and drying in the oven.

3. 4: Statistical Analysis

3.4.1 Analysis of Variance

The form of analysis of variance for parents and their progenies tested in one location is presented in Table 3.3

.

Table 3.4: Form of analysis of variance for one location

Source	df	ms	ems
Replication	(r- 1)		
Entries	(e- 1)	M_2	$\sigma^2 + r\sigma^2 g$
Error	(r- 1) (e- 1)	M_1	σ^2
Total	(r e – 1)		

Where:

r = number of replications

e = number of entries

σ^2 g = total genetic variance

σ^2 = error variance

ms = mean squares

ems = expectation of mean squares

$$\sigma^2 g = \frac{M_1 - M_2}{r}$$

$$\sigma^2 ph = \sigma^2 g + \frac{\sigma^2 e}{r}$$

(Allard, 1960)

The form of analysis of variance for parents and their progenies tested in two locations is presented in Table 3.5

Table 3.5: Form of analysis of variance across locations

Source	df	ms	ems
Loc	(l-1)		
Rep (loc)	l(r - 1)		
Entries	(e-1)	M_1	$\sigma^2 + r\,\sigma^2 gl + rl\,\sigma^2 g$
Entries x loc	(e - 1) (l -1)	M_2	$\sigma^2 + r\,\sigma^2 gl$
Error	l(r- 1) (e-1)	M_3	σ^2
Total	(lre - 1)		

Food and Agriculture Organization web site (2002)

www.fao.org/DOCREP/005/Y4391E/y4391e07.htm.

3. 4. 1. 1 *Estimates Components of Variance*

$$\sigma^2 g = \frac{M_1 - M_2}{rl}$$

$$\sigma^2 gl = \frac{M_2 - M_3}{r}$$

$$\sigma^2 ph = \sigma^2 g + \frac{\sigma^2 e}{rl} + \frac{\sigma^2 gl}{r}$$

Where:

r = number of replications

σ^2 g = total genetic variance

σ^2 gl = genotype by location Variance

σ^2 = error variance

rl = replication within location

ms = mean squares

ems = expectation of mean squares

σ^2 ph = Phenotypic variance for combined locations

3. 4. 1. 2 *Broad Sense Heritability Estimates*

$$H = \frac{\sigma^2 g}{\sigma^2 ph}$$

Genetic advance **=** K ($\sqrt{\sigma^2 ph}$) H. where K = selection differentials (2.062), H= broad sense heritability and ($\sqrt{\sigma^2 ph}$) = standard error of phenotypic variance (Allard, 1960)

3. 4. 2. Form of Analysis of Variance for Design II

The form of analysis of variance for design II, when males are crossed to females and evaluated in one location is illustrated in Table 3.6.

Table 3.6: Form of analysis of variance for design II experiment in one location

Source	df	ms	ems
Replication	r - 1		
Males	m - 1	M_5	$\sigma^2 + \sigma^2 + r\sigma^2_{fm} + rf\sigma^2_m$
Females	f - 1	M_4	$\sigma^2 + \sigma^2 + r\sigma^2_{fm} + rm\sigma^2_f$
Males x females	(m -1)(f – 1)	M_3	$\sigma^2 + r\sigma^2_{fm}$
Error	(r -1)(mf -1)	M_2	σ^2
Total	(rmf -1)	M_1	

The model for the anova is $X_{ijk} = \mu + r_k + a_i + a_j + d_{ij} + p_{ijk.}$

Where:

X_{ijk} = Effect of i^{th} genotype, l^{th} location and k^{th} replication

μ = Mean

r_k = Replication effect

$a_i - a_j$ = Additive effect

d_{ij} = Dominance effect

p_{ijk} = Experimental error

df = Degrees of freedom

ms = Mean squares

σ^2 = Error variance

σ^2_{fm} = Variance male x female

σ^2_m = Variance males

σ^2_f = Variance females

m = Male

f = Female

r = Replication

$$\sigma^2 f_m = \frac{M_3 - M_2}{r}$$

$$\sigma^2_m = \frac{M_5 - M_3}{rf}$$

$$\sigma^2_f = \frac{M_4 - M_3}{rm}$$

The form of analysis of variance for design II experiment, when males are crossed to females and evaluated in two locations is illustrated in Table 3.7

Table 3.7: Form of analysis of variance for design II experiment across locations

Source	df	ms	ems
Location (l)	(l-1)		
Replication (loc)	l (r-1)		
Males	(m-1)	M_7	$\sigma^2 + r\sigma^2_{fml} + rl\sigma^2_{fm} + rlf\sigma^2_m$
Females	(f -1)	M_6	$\sigma^2 + r\sigma^2_{fml} + rl\sigma^2_{fm} + rlm\sigma^2_f$
Males x Females	(m-1)(f-1)	M_5	$\sigma^2 + r\sigma^2_{fml} + rl\sigma^2_{fm}$
Males x l	(m-1)(l-1)	M_4	$\sigma^2 + r\sigma^2_{fml} + rf\sigma^2_{ml}$
Female x l	(f-1) (l-1)	M_3	$\sigma^2 + r\sigma^2_{fml} + rm\sigma^2_{fl}$
Male x female x l	(m-1)(f-1)(l-1)	M_2	$\sigma^2 + r\sigma^2_{fml}$
Error	l(r-1)(mf-1)	M_1	σ^2
Total	(lrmf-1)		

The model of the anova is $X_{ijk} = \mu + r_k + a_i + a_j + d_{ij} + a_{ie} + a_{je} + d_{ije} + p_{ijk.}$

Where:

X_{ijk} = Effect of i^{th} genotype, l^{th} location and k^{th} replication

μ = Mean

r_k = Replication effect

$a_i - a_j$ = Additive effects

d_{ij} = Dominance effect

$a_{ie} - a_{jl}$ = Interaction of Additive effects with location

d_{ijl} = Interaction of Dominance effects with location

p_{ijk} = Experimental error

df	=	Degrees of freedom
l	=	Location
r	=	Replication
m	=	Male parent
f	=	Female parent
ms	=	Mean squares
σ^2	=	Error variance
σ^2_{fml}	=	Variance male x female x location
σ^2_{fm}	=	Variance male x female
σ^2_{f}	=	Variance female
σ^2_{m}	=	Variance male
σ^2_{ml}	=	Variance male x location
σ^2_{fl}	=	Variance female x location

3.4.2.1 *Estimates of Male, Female and Male x Female Variances*

From the anova, the male, female and male x female variances and their interactions with location were calculated from the following formulae:

$$\sigma^2_{fml} = \frac{M_2 - M_1}{r}$$

$$\sigma^2_{ml} = \frac{M_4 - M_2}{fr}$$

$$\sigma^2_{fl} = \frac{M_3 - M_2}{mr}$$

$$\sigma^2_{fm} = \frac{M_5 - M_2}{rl}$$

$$\sigma^2_{m} = \frac{M_7 - M_5}{rlf}$$

$$\sigma^2_{f} = \frac{M_6 - M_5}{rlm}$$

3. 4. 2.2: *Additive and Dominance Genetic Variance Estimates*

For non-inbred parents, $\sigma^2_m = \sigma^2 f = ¼ \sigma^2 A$ (additive genetic variance),
$\sigma^2_{mf} = ¼ \sigma^2 D$ (dominance genetic variance) (Hallauer and Miranda, 1981).

3. 4. 3: Narrow Sense Heritability Estimates

Estimation of narrow sense heritability can be obtained from the σ^2_A from male and female components of variance. For non-inbred parents and no epitasis, $\sigma^2 A = 4 \sigma^2_m$.

Narrow sense heritability for one location

$$h^2 = \frac{4 \sigma^2_m}{\sigma^2 / (rf) + 4 \sigma^2_{mf/f} + 4 \sigma^2_m}$$

Narrow sense heritability across locations

$$h^2 = \frac{4\sigma^2_m}{\sigma^2 / (rfl) + 4 \sigma^2_{fml/(fl)} + 4 \sigma^2_{me/l} + 4 \sigma^2_{mf/f} + 4 \sigma^2_m}$$

Where:
σ^2_m = variance male

σ^2_{fml} = variance male x female x location

σ^2_{ml} = variance male x location

σ^2_{mf} = variance male x female

rfl = replication x female x location

fl = replication x female

σ^2 = error variance

(Hallauer and Miranda, 1981)

3. 4. 4: Heterosis

Heterosis was used to compare between the parents and their progenies in inheritance of desirable traits. Information on heterosis is critical to breeders of cross pollinated crops such as maize Yusuf *et al.* (2009). The goal of maize breeding is to obtained new hybrids that will out perform their parents with respect to certain traits Drinic *et al*. (2012). Heterosis for individual crosses for separate traits was calculated using the formulae below:

$$\text{High parent heterosis} = \frac{F_1 - H_p}{H_p} \times 100$$

$$\text{Mid parent heterosis} = \frac{F_1 - [(P_1 + P_2)/2]}{(P_1 + P_2)/2} \times 100$$

Where: F_1 = Mean performance of hybrids

H_p = Mean performance of high Parent

P_1 = Parent 1

P_2 = Parent 2

To test the significance of heterosis is computed using the formula by Paschal and Wilcox. (1975):

For one location

$$\text{Mid parent SD} = t \left(\sqrt{\frac{3MSG}{2r}} \right) \qquad \text{High parent SD} = t_r \left(\sqrt{\frac{2MSG}{r}} \right)$$

For the combined locations

$$\text{Mid parent SD} = t\left(\sqrt{\frac{3MSGL}{2r}}\right) \qquad \text{High parent SD} = t\left(\sqrt{\frac{2MSGL}{r}}\right)$$

SD = Differences between F_1 and mid parent or high parent required for significance at 5 % and 1% levels of probability.

t = tabulated t value at 5% and 1% level of probability and error degrees of freedom

MSGL= mean square of genotype x location from analysis of variance

r = number of replications

MSG = mean squares of genotype from analysis of variance

3. 4. 5: Correlations

Correlation was calculated between oil content and the various traits measured using the following formulae by Elsiddiq *et al.* (2004):

$$\text{Genotypic correlation} = \frac{\sigma g_1 g_2}{\sqrt{\sigma^2 g_1 \, \sigma^2 g_2}}$$

$$\text{Phenotypic correlation} = \frac{\sigma p_1 p_2}{\sqrt{\sigma^2 p_1 \, \sigma^2 p_2}}$$

Where:

$\sigma g_1 g_2$ is the genotypic covariance of characters X_1 and X_2

$\sigma^2 g_1$ and $\sigma^2 g_2$ are the genotypic variances of characters X_1 and X_2, respectively.

$\sigma p_1 p_2$ is the phenotypic covariance of characters X_1 and X_2

$\sigma^2 p_1$ and $\sigma^2 p_2$ are the phenotypic variances of characters X_1 and X_2, respectively.

3. 4. 6: Path Analysis

These are contributions i.e. the direct and the indirect affects between the oil content and the various traits measured.

1. These are the direct contributions, i.e. between the oil content which is the dependent variable and independent variables (plant height, number of leaves per plant, ear length, ear height, number of kernels per row, number of kernel rows, 100 grain weight and grain yield.
2. These are the indirect contributions via the independent variables themselves.

The direct contributions were obtained using matrix method

Singh and Chaudhary. (1977).

Excel was used in the calculations as follows:

- Create columns by columns on the excel work sheet according to the number of Independent variables.
- Highlight all the genotypic correlations coefficients between the independent variables.
- Write {=MINVERSE (cell address)} containing the independent variables on the first column of the highlighted space.
- Press shift, control, and F_6 keys at the same time then press enter key.
- Values were obtained.

- Highlight the above values.
- Create columns again according to the number of independent variables
- Write {=MMULT(cell address)} on the first column of created space
- Press shift, control, and F_6 keys at the same time, then press enter key
- The values obtained are the direct contributions designated as (P_n).

The Indirect contributions were obtained thus:

Multiplying the direct contributions by genotypic correlation coefficient (P_n, gr)

P_n =Direct contribution coefficient of independent variables

gr =correlation coefficient between variables

The direct and indirect contributions were obtained as:

$$r_{1y} = \mathbf{P_{1y}} + r_{12} P_{2y} + r_{13} P_{3y} + r_{14} P_{4y} + r_{15} P_{5y} + r_{16} P_{6y} + r_{17} P_{7y} + r_{18} P_{8y}$$

$$r_{2y} = r_{12} P_{1y} + \mathbf{P_{2y}} + r_{23} P_{3y} + r_{24} P_{4y} + r_{25} P_{5y} + r_{26} P_{6y} + r_{27} P_{7y} + r_{28} P_{8y}$$

$$r_{3y} = r_{13} P_{1y} + r_{23} P_{2y} + \mathbf{P_{3y}} + r_{34} P_{4y} + r_{35} P_{5y} + r_{36} P_{6y} + r_{37} P_{7y} + r_{38} P_{8y}$$

$$r_{4y} = r_{14} P_{1y} + r_{42} P_{2y} + r_{43} P_{3y} + \mathbf{P_{4y}} + r_{45} P_{5y} + r_{46} P_{6y} + r_{47} P_{7y} + r_{48} P_{8y}$$

$$r_{5y} = r_{15} P_{1y} + r_{52} P_{2y} + r_{53} P_{3y} + r_{54} P_{4y} + \mathbf{P_{5y}} + r_{56} P_{6y} + r_{57} P_{7y} + r_{58} P_{8y}$$

$$r_{6y} = r_{16} P_{1y} + r_{62} P_{2y} + r_{63} P_{3y} + r_{64} P_{4y} + r_{65} P_{5y} + \mathbf{P_{6y}} + r_{67} P_{7y} + r_{68} P_{8y}$$

$$r_{7y} = r_{17} P_{1y} + r_{72} P_{2y} + r_{73} P_{3y} + r_{74} P_{4y} + r_{75} P_{5y} + r_{76} P_{6y} + \mathbf{P_{7y}} + r_{78} P_{8y}$$

$$r_{8y} = r_{18} P_{1y} + r_{82} P_{2y} + r_{83} P_{3y} + r_{84} P_{4y} + r_{85} P_{5y} + r_{86} P_{6y} + r_{87} P_{7y} + \mathbf{P_{8y}}$$

Singh and Chaudhary. (1977).

CHAPTER 4

RESULTS

4.1: Analysis of Variance

The mean square result for Samaru is presented in Table 4.1. It indicated that Plant height, number of leaves per plant, ear length, number of kernels per row and grain yield per hectare showed highly significant differences (P = 0.01) among the entries (genotypes), while ear height showed significant difference (P = 0.05). Result for Kadawa (Table 4.2) indicated plant height, number of leaves per plant, ear height, number of kernels per row, number of kernel rows and yield per hectare showed highly significant differences (P = 0.01). For the combined locations (Table 4.3), the genotypes indicated highly significant differences (P = 0.01) for all the traits except 100 grain weight, which did not indicate any significant difference. For entries by location interaction, plant height, ear length, ear height, number of kernels per row and number of kernel rows indicated highly significant differences (P = 0.01), the other traits were not significant.

4.1.1: Mean Performance of Male, Female Parents and Their Progenies

The performance values at Samaru were presented in Tables 4.4 and 4.5. The Highest performance values among the parents and their progenies for plant height, number of leaves per plant, ear length, ear height, number of kernels per row, number of kernel rows, percent oil, 100 grain weight and grain yield were recorded on the following varieties, SDM2, Ex- Yola DT x Sweet corn white, Sweet corn yellow, Sammaz 27 x Sweet corn white, Sammaz 18 x Sweet corn yellow, Sammaz 27 x Sweet corn yellow, Sweet corn yellow, Sammaz 27 and Sammaz 20.

Table 4.1 Analysis of variance for nine agronomic traits of maize evaluated at Samaru in 2011

Source	df	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100GW	GY kg/ha
Rep	2	33.78	0.15	6.72	64.19	11.22	2.63	0.265	3.153	9854014.04
Entries	31	981.47**	3.033**	7.19**	186.42*	39.89**	2.95	0.202	2.557	3064073.92**
Error	62	331.61	1.28	1.94	103.78	17.47	1.98	0.279	4.389	513722.7
Total	95									

** Significant at 1% level of probability. * Significant at 5% level of probability

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear height, cm. EH = ear height, cm. NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = percent oil, 100 GW = One hundred grain weight, gm. GY kg/ha = Grain yield per hectare

Table 4.2 Analysis of variance for nine agronomic traits of maize evaluated at Kadawa in 2011

Source	df	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100GW	GY kg/ha
Rep	2	349.25	0.94	3.43	38.24	5.48	0.11	5.66	25.56	81782.55
Entries	31	358.63**	2.76**	5.01	204.43**	67.42**	8.87**	0.28	5.32	2382765.15**
Error	62	142.14	1.16	3.25	95.88	8.52	103.11	0.19	4.40	239795.19
Total	95									

** Significant at 1% level of probability. * Significant at 5% level of probability

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear height, cm. EH = ear height, cm NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight, gm. Gykg/ha = Grain yield per hectare

Table 4.3: Analysis of variance for nine agronomic traits of maize evaluated across locations in 2011

Source	df	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100GW	GY kg/ha
Location	1	385.33	0.33	2.29	5764.1	166.88	0.88	11.2	0.61	13002.1
Reps (loc)	4	147.78	0.39	5.31	55.12	3.8	1.7	3.3	31.40	4574880.2
Entries	31	834.32**	5.1**	7.04**	216.64**	83.21**	7.0**	0.381**	24.41	4618427**
Entries x loc	31	508.44**	0.32	4.89**	195.63**	26.42**	4.1**	0.122	20.84	600130
Error	124	243.97	1.30	2.64	112.0	12.27	1.80	0.14	21.78	531830.2
Total	191									

* * Significant at 1% level of probability * Significant at 5% level of probability

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear height, cm. EH = ear height, cm. NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. GY kg/ha = Grain yield per hectare.

The performance values for parents and their progenies at Kadawa are presented in Tables 4.6 and 4.7. The Highest performance values among the parents and their progenies for plant height, number of leaves per plant, ear length, ear height, number of kernels per row, number of kernel rows, percent oil, 100 grain weight and grain yield per hectare were recorded on the following varieties, Oba super 2 x Sweet corn white, SDM2, Sammaz 18 x Sweet corn yellow, Ex- Yola DT x Sweet corn white, Sammaz 18 x Sweet corn yellow, Ex- Yola DT, Sweet corn white, Sammaz 18 x Sweet corn yellow, Oba super 2. The performance values for the combined locations were presented in Tables 4.8 and 4.9. The Highest performance values among the parents and their progenies for plant height, number of leaves per plant, ear length, ear height, number of kernels per row, number of kernel rows, percent oil, 100 grain weight and grain yield per hectare were recorded on the following varieties, SDM2, Sammaz 36, Sammaz 18 x Sweet corn yellow, Sammaz 27 x Sweet corn white, Sammaz 18 x Sweet corn yellow, SDM2 x Sweet corn white, Sweet corn yellow, Sammaz 18 x Sweet corn yellow and Sammaz 20. Samaru location recorded the highest grand mean for number of kernels per row, percent oil and grain yield per hectare over Kadawa while Kadawa recorded the highest grand mean for the rest of six traits.

Table 4.4 Mean performance of parents for nine agronomic traits of maize evaluated at Samaru in 2011

MALE PARENTS	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100_{GW}	GY kg/ha
1. SWEET CORN WHITE	125.33c - h	12.33d - f	18.66a - b	64.00a - d	10.66-d	10.66-d	3.53-b	20.6a-b	473.3-h
2. SWEET CORN YELLOW	156.67a - d	13.66a - f	19.00-a	45.00d - e	12.00c - d	12.00c - d	4.66-a	18.56-b	303.3-h
MEAN	**141.00**	**12.99**	**18.83**	**50.45**	**11.33**	**11.33**	**4.09**	**19.5-6**	**388.3**
FEMALE PARENTS									
1 OBA SUPER 2	96.67-h	14.66a - c	15.66c - f	44.33d - e	26. 33g - h	12.00c - d	3.56b	19.93a - b	3666.7b - e
2 EX –YOLA DT	124.00d - h	14.33a - c	13.66d - f	53.00a - e	27.33 a - c	14.00a - c	3.9ab	19.16a - b	4333a - b
3 SAMMAZ 18	143.77a - f	13.50a - f	16.00c - e	54.00a - e	37.25 a - c	12.75a - d	3.67a - b	19.9a - b	2975b - g
4 SAMMAZ 20	127.50c - h	12.00d - f	14.00d - f	49.50a - e	28.67 e- h	13.00a - d	3.9a - b	19.10a - b	5050-a
5 SAMMAZ 36	120.67d - h	14.00a - e	14.00d - f	51.33a - e	32.33 b -h	13.33a - d	3.66a - b	19.80a - b	2633.3d - g
6 SDM 2	175.00-a	15.00a - b	14.33d - f	46.00c - e	35.00 a - f	13.33a - d	3.7a - b	19.80a - b	2733de - g
7 SAMMAZ 27	137.33b - g	11.66-f	16.00c - e	39.66-e	31.66 b - f	12.00c - d	3.66a - b	23.00-a	1800f - g
8 SAMMAZ 37	143.67a - g	14.66a - c	14.33d - f	47.00c - e	29.66 c - f	13.33a - d	3.43-b	20.6a - b	2400e - g
9 SAMMAZ 13	102.00a - d	14.33a - d	16.00c - e	39.00-e	32.66 b - f	13.66a - c	3.56-b	19.36a - b	2733d - g
10 SAMMAZ 29	124.67d - h	13.66a - f	15.33c - f	45.00d - e	33.66 a - f	13.00a - d	3.7a - b	18.53a - b	2000f - g
MEAN	**136.16**	**13.48**	**14.93**	**46.88**	**13.04**	**13.04**	**3.67**	**19.9**	**3032.37**

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH =ear height. NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. GY kg/ha = Grain yield per hectare

Table 4.5 Mean performance of progenies for nine agronomic traits of maize evaluated at Samaru in 2011

HYBRIDS		PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100_{GW}	GY kg/ha
1 OBA SUPER 2 x sweet corn yellow		147.00a - f	13.66a - f	13.167-f	42.33-e	31.33a - h	14.66a - c	3.96a - b	20.16a - b	4033a- d
2 EX –YOLA DT	,,	145.00a - f	12.33d - f	16.33b - d	50.66a - e	35.00a - f	13.33a - d	4.00a - b	18.9a - b	3200b - g
3 SAMMAZ 18	,,	173.33a - b	12.00e - f	18.66a - b	57.00a - e	41.66-a	13.33a - d	3.66a - b	20.8a - b	3200b - g
4 SAMMAZ 20	,,	141.75a - f	13.66a - f	15de - f	52.33a - e	33.00b - h	12.33a - d	4.03a - b	19.26a - b	2066.7f - g
5 SAMMAZ 36	,,	161.67a - c	13.33a - f	16.33b - d	68.33a - b	34.00a - h	12.66a - d	4.06a - b	20.06a - b	4000a - d
6 SDM 2	,,	141.33a - f	14.66a - c	14.66d - f	49.66a - e	33.00b - h	13.00a - d	3.6a - b	20.26a - b	2166.7f - g
7 SAMMAZ 27	,,	111.67f - h	12.00d - f	14.66d - f	45.66d - e	25.66-h	15.33-a	3.76a - b	19.53a - b	3200b - g
8 SAMMAZ 37	,,	117.00e - h	12.66c - f	18.00a - c	49.00a - e	31.33b - h	14.00a - c	3.9a - b	19.96a - b	2833c - g
9 SAMMAZ 13	,,	145.00a - f	12.66c - f	15.66c - f	49.66a - e	35.00a - f	13.33a - d	3.76a - b	19.86a - b	2333.3e - g
10 SAMMAZ 29	,,	156.00a - d	13.00b - f	13.33e - f	49.00a - e	37.00a - d	13.66a - c	4.00a - b	18.90a - b	3133b - g
MEAN		**144.00**	**13.00**	**15.6**	**56.00**	**30.5**	**13.6**	**3.86**	**19.8**	**3016**
1 OBA SUPER 2 x sweet corn white		119.00e - h	14.33a - d	13.00-f	48.33b - e	29.66c - h	12.66b - d	3.56 - b	18.93a -b	4233a - c
2 EX –YOLA DT	,,	151.67a - e	15.33-a	14.33d- f	47.00c -e	33.66a - h	13.00a - d	3.83a - b	18.6-b	3633.3b - e
3 SAMMAZ 18	,,	138.00b - g	13.33a - f	15.66c - f	43.66de	33.00b - h	12.66a - d	3.8a - b	19.36a - b	1833.3f - g
4 SAMMAZ 20	,,	132.33c - g	14.00a - e	14.00d - f	48.33bc - e	34.66a - g	13.33a - d	3.83a - b	18.4-b	2400e - g
5 SAMMAZ 36	,,	138.00b - g	12.33d - f	14.66d - f	40.00-e	31.67b - h	12.00c - d	4.2a - b	19.83a - b	2533.3e - g
6 SDM 2	,,	136.67c - g	12.00d - f	14.33d - f	39.66-e	39.00a - b	15.00a - b	3.5-b	19.23a - b	2000f-g
7 SAMMAZ 27	,,	139.00b - f	13.33a - f	16.00c - e	68.66-a	30.66b - h	13.66a - c	3.3-b	19.7a - b	3333.3b - f
8 SAMMAZ 37	,,	125.00c - h	13.00a - f	14.66d - f	66.33a - c	36.00a - e	14.66a - c	3.8a - b	20.33a - b	3100b - f
9 SAMMAZ 13	,,	127.33c - h	12.33d - f	15.33c - f	46.33c - e	28.33e - h	13.33a - d	4.03a - b	18.96a - b	1760-g
10 SAMMAZ 29	,,	123.00d - h	12.66c - f	14.66d - f	47.33c - e	31.66b - h	14.66a - c	3.7a - b	21.0a - b	1966.7f - g
MEAN		**133.00**	**13.3**	**15.00**	**50.00**	**32.8**	**13.5**	**3.7**	**19.4**	**2679**
CV%		13.39	8.48	9.08	20.52	12.79	10.63	13.95	10.63	26.27
GRAND MEAN		**135.98**	**13.34**	**15.32**	**49.66**	**32.67**	**13.24**	**3.79**	**19.71**	**2727.4**
SE ±		18.21	1.13	1.39	10.19	4.18	1.41	0.53	2.09	716.7

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm. NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. GY kg/ha = Grain yield per hectare

Table 4.6 Mean performance of parents for nine agronomic traits of maize evaluated at Kadawa in 2011

MALE PARENT	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100_{GW}	GY/kg/ha
1 SWEET CORN WHITE	141.66a - e	14.33a - d	15.33b - e	60.66a - e	36.66a - c	9.33e - f	4.3-a	18.2b - c	266-k
2 SWEET CORN YELLOW	131.00b - f	13.66a -f	16.66a - e	59.33a - e	38.66-a	8.66f - g	4.1a - b	20.4b- c	150-k
MEAN	**136.33**	**15.49**	**15.99**	**59.99**	**37.66**	**8.9**	**4.2**	**19.3**	**208**
FEMALE PARENTS									
1 OBA SUPER 2	136.33b - f	15.00a - b	17.00a - d	71.33a - e	30.33f - j	12.66c -e	3.3b-c	18.5b - c	4466.7-a
2 EX –YOLA DT	118.00e - f	13.66a - f	14.66c - e	52.66c - f	28.00h - l	16.66a	3.13-c	22.4a - b	3633.3a - d
3 SAMMAZ 18	151.33a - b	13.33b - f	15.00b - e	53.00c - f	27.33h - l	14.33a - c	3.1-c	21.8a - c	2766.7d - j
4 SAMMAZ 20	122.00d - f	13.33b - f	14.00c - e	56.66c - f	29.66f - k	14.33a - c	3.5a - c	21.0a - c	3433.3b -e
5 SAMMAZ 36	141.00a - e	13.66a - f	17.00a - d	65.00a - e	28hi - k	15.66a - b	3.56a - c	20.5a - c	2566e - j
6 SDM 2	145.66a - d	15.66-a	16.66a - e	76.33a - b	22.66l - m	13.66b - e	3.3b-c	21.7a - c	2966.7c - h
7 SAMMAZ 27	123.66d - f	12.00-f	15.33b - e	68.66a - e	30.00f - k	12.00c - e	3.56a - c	19.0b - c	1833-j
8 SAMMAZ 37	116.66-f	14.66a - c	14.66c - e	51.66d - f	25.66i - m	13.33b - e	3.26-c	19.7bc	2700d - j
9 SAMMAZ 13	118.33e - f	14.33a - d	13.66d - e	50.00d - f	28.66g - k	12.66c - e	3.3b-c	19.1bc	2900c - i
10 SAMMAZ 29	126.66c - f	13.33b - f	15.66b - e	39.66-f	30.00f - k	13.66c - e	3.26-c	20.1bc	1933.3i - j
MEAN	**129.96**	**13.89**	**15.36**	**61.76**	**28.03**	**13.89**	**3.3**	**20.4**	**2623.23**

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height. cm NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. GY kg/ha = Grain yield per hectare

Table 4.7 Mean performance of progenies for nine agronomic traits of maize evaluated at Kadawa in2011

HYBRIDS	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100_{GW}	Gykg/ha
1 OBA SUPER 2 X sweet corn yellow	139.66a - f	13.66a - f	15.33b - e	61.00a - e	32.66b - h	14.00b - d	3.0-c	21.6a - c	2700d - j
2 EX –YOLA ,,	142.33a - d	12.33d - f	16.00a - e	55.33c - f	27.66h - l	12.33c - e	3.0-c	21.2a - c	3100b - g
3 SAMMAZ 18 ,,	145.00a - d	12.33d - f	19.33-a	67.66a - e	38.33-a	11.66d - e	3.3b - c	24.4-a	2666.7e - j
4 SAMMAZ 20 ,,	134.33b - f	13.66a - f	15.66b - e	64.33a - e	31.33d - i	12.00c - e	3.2-c	21b-c	2133g - j
5 SAMMAZ 36 ,,	141.00a - e	13.00b - f	15.66b - e	53.33c - f	29.33g - k	12.00c - e	3.4b - c	18.9b - c	2533.3d - j
6 SDM 2 ,,	148.00a - c	14.66a - c	15.00b - e	58.33b - f	30.66e - j	14.00b - d	3.6a - c	19.7b-c	2566.7e - j
7 SAMMAZ 27 ,,	132.66b - f	12.33d - f	13.33-e	61.66a - e	24.33k - m	11.33e - f	3.4b-c	19.2b-c	2700d - j
8 SAMMAZ 37 ,,	133.66b - f	12.66c - f	15.33b - e	54.00c - f	31.66c - h	14.33b - c	3.13-c	19.1b-c	2366f - j
9 SAMMAZ 13 ,,	153.00a - b	13.00b - f	15.33b - e	72.33a - c	37.66a - b	12.66c - e	2.86-c	20.8a - c	2600e - j
10 SAMMAZ 29 ,,	150.66a - c	13.00b - f	15.00b - e	56.00c - f	37.00a - c	14.00b - d	3.3b-c	20.1b - c	3233b - f
MEAN	**142.00**	**13.1**	**15.6**	**60.4**	**32.1**	**12.8**	**3.2**	**20.6**	**2659.8**
1 OBA SUPER 2 x sweet corn white	161.00-a	14.66a - c	14.00c - e	61.00a - e	21.33-m	14.00b - d	3.2-c	20.3a - c	2733a - c
2 EX –YOLA DT ,,	152.33a - b	15.00a - b	14.66c - e	78-a	27.33h - l	13.66b - e	3.13-c	19.7b - c	4000a - b
3 SAMMAZ 18 ,,	148.66a - e	13.33b - f	18.33a - b	68.66a-e	32.33c - h	13.66b - e	3.4b-c	18.7b - c	1933i - j
4 SAMMAZ 20 ,,	141.33a - e	14.00a - e	17.33a - c	67.00a - e	36.00a - e	12.66c - e	3.0-c	20.5a - c	1900-j
5 SAMMAZ 36 ,,	132.66b - f	12.33d - f	15.33b - e	63.66a - e	32.66b - h	15.33a - b	3.16-c	19.8b - c	2433.3f - j
6 SDM 2 ,,	130.66b - f	11.66-f	15.00b - e	51.66d - f	37.33a - b	16.66-a	3.6a - c	21.1a - c	3033.3c - g
7 SAMMAZ 27 ,,	139.00a - f	13.33bc - f	16.33a - e	67.33a - e	25.33j - m	14.00b - d	3. 2-c	18.1b - c	3266.7b - f
8 SAMMAZ 37 ,,	133.00b - f	13.00b - f	14.66c - e	66.00a - e	35.33a - f	12.33c - e	3.16-c	19.9b - c	3333.3b - f
9 SAMMAZ 13 ,,	139.66a - f	12.66c - f	15.00b - e	65.33a - e	25.00k - m	12.66c - e	3.56a - c	19.3b-c	2033h - j
10 SAMMAZ 29 ,,	138.00a - f	13.33b - f	14.66c - e	63.66a - e	34.33a - h	14.33a - c	3.4b - c	19.7b-c	2400f - j
MEAN	**142.00**	**13.3**	**15.5**	**65.2**	**30.1**	**14 .00**	**3.2**	**19.7**	**2705.5**
C.V %	8.65	8.00	11.62	15.97	9.49	9.73	12.98	10.39	18.54
GRAND MEAN	**137.78**	**13.47**	**15.53**	**61.30**	**30.74**	**13.26**	**3.35**	**20.18**	**2640.1**
SE ±	11.92	1.09	1.80	9.79	2.92	1.29	0.43	2.09	489.6

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. GY kg/ha = Grain yield per hectare

Table 4.8: Mean performance of parents for nine agronomic traits of maize evaluated across locations in 2011

MALE PARENT	PLTH	NOL	EL	EH	NKP	NKR	%OIL	100_{GW}	GY kg/ha
1 SWEET CORN WHITE	133.50b - i	13.33c - j	17.00a - c	62.33a - c	35.00b - h	10.00-g	3.9a - b	19.40-b	370-i
2 SWEET CORN YELLOW	143.83a - g	13.66b - i	17.83a - b	52.16b - e	37.50a - c	10.00-g	4.4 -a	19.50a - b	226.7-i
MEAN	**138.66**	**13.50**	**17.41**	**57.25**	**36.25**	**10.00**	**4.2**	**19.45**	**298.35**
1 OBA SUPER 2	116.50i - j	14.83a - c	16.33b - e	57.83a - d	30.16h - m	12.33e - f	3.45-b	19.23b	4066-a
2 EX –YOLA DT	121.00h - j	14.00a - f	14.16e - f	52.83b - e	27.66j - m	15.33a - b	3.51-b	20.78a - b	3983a - b
3 SAMMAZ 18	147.00a - e	13.42d - i	15.57c - f	53.86b - e	33.00c - i	13.43c - f	3.42-b	20.70a - b	2885d - f
4 SAMMAZ 20	124.00f - j	12.60f - j	14.00e - f	53.80b - e	29.20i - n	13.60b - f	3.66-b	20.26a - b	4080-a
5 SAMMAZ 36	130.833c - j	18.33-a	15.50c – f	58.17a - d	31.66e - k	15.50a - c	3.61-b	20.15a - b	2600d - h
6 SDM 2	160.33-a	15.3bc - h	15.50c -f	61.17a - c	27.50k - n	13.50b - f	3.52-b	20.75a - b	2850d - f
7 SAMMAZ 27	130.50c - j	11.83-j	15.66b - f	54.16a - e	28.16g - l	12.00-f	3.61-b	21.03a - b	1816.7-h
8 SAMMAZ 37	130.16c - j	14.66a - d	14.50d - f	49.33c - e	27.66j - n	13.33c - f	3.35-b	20.16a - b	2550de - h
9 SAMMAZ 13	110.16-j	14.33a - f	14.83c - f	44.50d - e	30.66i - n	13.16c - f	3.43-b	19.25-b	2816.7d - g
10 SAMMAZ 29	125.66e - j	13.50c - i	15.50c - f	42.33-e	29.33i - n	13.33c - f	3.48-b	19.32-b	1966g - h
MEAN	**129.65**	**14.28**	**15.15**	**52.79**	**29.49**	13.55	**3.5**	**20.1**	**2524.6**

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH= ear night NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. GY kg/ha = Grain yield per hectare

Table 4.9: Mean performance of progenies for nine agronomic traits of maize evaluated across locations in 2011

HYBRIDS	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100_{GW}	GY kg/ha
1 OBA SUPER 2 x sweet corn yellow	143.33a - g	13.66b - i	14.25e - f	51.66c - e	32.00e - k	14.33a - d	3. 50-b	20.9a - b	3366.7a - d
2 EX –YOLA DT ,,	143.66a - g	12.33h - j	16.16b - e	53.00b - e	31.83f - k	12.83c - f	3.52-b	20.06a - b	3150b - e
3 SAMMAZ 18 ,,	159.167-a	12.16i - j	19.00-a	62.33a - c	40.00-a	12.50d - f	3.48-b	22.60-a	2933.3c - f
4 SAMMAZ 20 ,,	137.66b - i	13.66b - i	15.33c - f	58.33a - d	32.16d - k	12.16-f	3.63-b	20.13a - b	2100f - h
5 SAMMAZ 36 ,,	151.33a - c	13.16d - i	16.00b - e	60.00a - c	31.66e - k	12.33e - f	3.75a - b	19.50a - b	3366.7a - e
6 SDM 2 ,,	144.66a - f	14.66a - d	14.83c - f	54.00a - e	31.83e - k	13.50b - f	3.61-b	20.00a - b	2366e - h
7 SAMMAZ 27 ,,	122.16g - j	12.16i - j	14.00e - f	53.66b - e	25.00-n	13.13c - f	3.58-b	19.37-b	2950.0c - f
8 SAMMAZ 37 ,,	125.33e - j	12.66g - j	16.66b - d	51.50c - e	31.50e - l	14.16a - e	3.32-b	19.51-b	2600d - j
9 SAMMAZ 13 ,,	149.00a - d	12.83f - j	15.50c - f	61.00a - c	36.33a - e	13.00c - f	3.52-b	20.13a - b	2966d - h
10 SAMMAZ 29 ,,	153.33a - b	13.00e - j	14.16e-f	52.50b - e	37.00a - d	13.33c - f	3.65-b	19.51-b	3183b - e
MEAN	**129.2**	**13.00**	**15.6**	**55.8**	**32.9**	**13.1**	**3.5**	**20.2**	**2898.2**
1 OBA SUPER 2 x sweet corn white	140.00a - h	14.5a - e	13.50-f	54.66a - e	25.50m - n	13.33c - f	3.4-b	19.61a - b	3983.3a - b
2 EX –YOLA DT ,,	152.00a - c	15.6-b	14.50d - f	62.50a - c	33.50g - l	13.33c - f	3.48-b	19.15-b	3816.7a - c
3 SAMMAZ 18 ,,	143.33a - g	12.33h - j	17.00a - c	56.17a - e	32.66d - j	13.16c - f	3.61-b	19.06-b	1883. 3-h
4 SAMMAZ 20 ,,	136.83b - j	14.0ab - g	15.66b - f	57.66a - d	35.33a - g	13.00c - f	3.41-b	19.47-b	2150f - h
5 SAMMAZ 36 ,,	135.33bc - i	12.33h - j	15.00c - f	51.53c - e	32.16d - k	13.66b - f	3.68-b	19.83a - b	2483d - h
6 SDM 2 ,,	133.66b - i	11.83-j	14.66c - f	45.66d - e	38.17a - b	15.83-a	3.55-b	20.15a - b	2515.7d - h
7 SAMMAZ 27 ,,	139.00a - h	13.33c - j	16.16b - e	68.00a	28.00i - n	13.83b - f	3.25-b	18.92b	3250.0a - e
8 SAMMAZ 37 ,,	129.00d - j	13.00e - j	14.66c - f	66.17a - b	35.66a - f	13.50b - f	3.48-b	20.10a - b	3216.7a - e
9 SAMMAZ 13 ,,	133.50b - i	12.50g - j	15.16c - f	55.83a - e	26.66l - n	13.00c - f	3.8a - b	19.17-b	1900.0-h
10 SAMMAZ 29 ,,	130.50c - j	13.00e - j	14.66c - f	55.50a - e	33.00c - i	14.50a - c	3.56-b	20.36a - b	2183.3f - h
MEAN	**137. 3**	**13.2**	**15.0**	**57.3**	**32.1**	**14.0**	**3.5**	**19.6**	**2738.2**
C.V %	11.27	8.19	10.67	17.99	11.28	10.17	15.13	10.79	24.69
GRAND MEAN	**136.88**	**13.40**	**15.42**	**55.48**	**31.71**	**13.25**	**3.54**	**19.95**	**2683.7**
S E ±	136.88	1.09	1.65	9.98	3.58	13.25	3.57	2.15	662.7

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. GY kg/ha = Grain yield per hectare

4.1.2: Components of Variance

Genotypic, phenotypic and environmental variances with their coefficients of variations for Samaru, Kadawa and the combined locations were presented in Tables 4.10, 4.11 and 4.12, respectively. At Samaru location (Table 4.10), the environmental variance had higher values over genotypic variance (σ^2g) for ear height, number of kernels per row, 100 grain weight and percent oil. The genotypic variance (σ^2g) had higher values over environmental variance (σ^2e) for plant height, number of leaves per plant, ear length, number of kernel rows and yield per hectare. The result for Kadawa (Table 4.11) indicated that environmental variance (σ^2e) had higher values for ear length, number of kernels per row, percent oil, 100 grain weight and grain yield per hectare while genotypic variance (σ^2g) had higher values for plant height, number of leaves per plant, ear height and number of kernel rows. The combined location estimates are presented in Table 4.12 which indicated genotypic variance (σ^2g) had higher values on all the traits relative to environmental variance except for ear height and 100 grain weight.

Table 4.10: Genotypic, phenotypic and environmental variances with co-efficient of variations for nine agronomic traits of maize at Samaru in 2011

Traits	σ^2_e	ecv %	σ^2_g	gcv %	σ^2_{ph}	pcv %
Plant height	110.53	7.7	216.26	10.8	372.16	14.2
Number of leaves per plant	0.43	4.9	0.58	5.7	1.01	7.5
Ear length	0.65	5.3	1.75	8.6	2.39	10.1
Ear height	34.59	11.81	27.55	10.6	62.14	15.9
Number of kernels per row	5.58	7.3	7.47	8.4	13.29	11.2
Number of kernel rows	0.66	6.1	0.32	4.3	0.98	7.5
Percent oil	0.09	8.0	-0.03	4.5	0.08	6.8
100 grain weight	1.46	6.1	-0.61	3.9	0.85	4.7
Grain yield kg/ha	171240.9	15.2	850117.1	33.8	1021357.9	37.1

σ^2_e = environmental variance, σ^2_g = genotypic variance, σ^2_{ph} = phenotypic variance.
ecv % = environmental coefficient of variation in percentage, gcv % genotypic coefficient of variation in percentage.
pcv % = phenotypic coefficient of variation in percentage.

Table 4.11: Genotypic, phenotypic and environmental variances with co-efficient of variations for nine agronomic traits of maize at Kadawa in 2011

Traits	σ^2_e	ecv %	σ^2_g	gcv %	σ^2_{ph}	pcv %
Plant height	47.36	4.9	72.16	6.2	119.54	7.9
Number of leaves per plant	0.39	4.6	0.53	5.4	0.92	7.0
Ear length	1.08	6.7	0.58	4.9	1.67	8.3
Ear height	31.96	9.2	36.18	9.8	68.14	13.5
Number of kernels per row	2.84	5.5	19.63	14.4	22.47	15.4
Number of kernel rows	34.37	44.2	-31.41	42.3	2.96	12.9
Percent oil	0.06	7.5	0.03	5.2	0.09	9.1
100 grain weight	1.47	5.9	0.31	2.7	1.77	6.5
Grain yield kg/ha	79931.73	10.6	71432	10.1	794255.05	33.75

σ^2_e = environmental variance, σ^2_g = genotypic variance, σ^2_{ph} = phenotypic variance.
ecv % = environmental coefficient of variation in percentage, gcv % genotypic coefficient of variation in percentage.
pcv % = phenotypic coefficient of variation in percentage.

Table 4.12: Genotypic, phenotypic and environment variances with co-efficient of variation for nine agronomic traits of maize across locations in 2011

Traits	σ^2_e	ecv %	σ^2_g	gcv %	σ^2_{gl}	glcv %	σ^2_{ph}	pcv %
Plant height	40.6	4.6%	54.3	5.4%	88.16	6.9%	183.1	9.9%
Number of leaves per plant	0.22	3.3%	7.9	21%	-0.33	4.3%	9.97	24%
Ear length	0.44	4.3%	0.36	3.9%	0.75	5.6%	1.55	8.1%
Ear height	18.6	7.8%	3.5	3.4%	27.87	9.5%	49.95	12.7%
Number of kernels per row	2.05	4.5%	9.5	9.7%	4.72	6.8%	16.3	30.5%
Number of kernel rows	0.3	4.1%	4.8	16.7%	0.77	6.6%	5.87	18.3%
Percent oil	0.023	4.3%	0.043	5.9%	-0.01	2.2%	0.06	6.7%
100 grain weight	3.63	9.5%	0.595	3.9%	-0.32	2.8%	3.91	9.9%
Grain yield kg/ha	88638.3	11.1%	669716.2	30.4%	22766.6	5.6%	781121.1	32.9%

σ^2_e = environmental variance, σ^2_g = genotypic variance, σ^2_{ph} = phenotypic variance.
ecv % = environmental co-efficient of variation in percentage, gcv % genotypic co-efficient of variation in percentage.
pcv % = phenotypic co-efficient of variation in percentage. glcv % genotype by location coefficient of variation in percentage.

4.1.3: Broad Sense Heritability Estimates

Broad sense heritability estimates were presented in Table 4.13 for Samaru, Kadawa and the combined locations. The result for Samaru indicated that plant height (0.6621), number of leaves per plant (0.5779), ear length (0.7301) and grain yield per hectare (0.8323) had high broad sense heritability estimates. Ear height (0.4433), number of kernel rows (0.5620), and number of kernels per row (0.3288) had moderate heritability estimates while percent oil and 100 grain weight had negative heritability estimates of (-0.3812 and -0.7164), respectively. The result for Kadawa indicated that number of kernel rows (0.8736), grain yield per hectare (0.8993) plant height (0.6033) and number of leaves per plant (0.5797) had high broad sense heritability estimates. Ear length and percent oil had low broad sense heritability estimates (0.3512, 0.3214, respectively). Ear height had a moderate heritability estimate (0.5309), while 100 grain weight had a very low broad sense heritability estimate (0.1729) and number of kernels per row had a negative broad sense heritability estimate (-10.8246). The result for the combined locations indicated that number of leaves per plant, number of kernel rows, number of kernels per row, percent oil and grain yield had high broad sense heritability estimates (0.81, 0.82, 0.60, 0.75, 0.85, respectively). Plant height, ear length, ear height and 100 grain weight had low heritability estimates (0.30, 0.23, 0.10, and 0.20, respectively). Broad sense heritability estimates at Samaru for all the traits indicated positive and high values excepts for percent oil and 100 grain weight which showed negative values, at Kadawa ear height, percent oil and 100 grain weight recorded very low estimates while number of kernel row showed negative estimate and the rest of the traits recorded high and positive estimates, for the combined

locations ear height, percent oil and 100 grain weight recorded very low estimates and the rest of traits recorded high and positive values.

Table 4.13: Broad sense heritability estimates and genetic advance estimates for nine agronomic traits for Samaru, Kadawa and across locations in 2011

Traits	Samaru		Kadawa		Across locations	
	H	GA	H	GA	H	GA
Plant height	0.6621	26.34	0.6036	13.60	0.30	8.37
Number of leaves per plant	0.5779	2.07	0.5797	1.14	0.810	5.27
Ear length	0.7301	1.19	0.3512	0.94	0.23	0.59
Ear height	0.4433	7.20	0.5309	9.04	0.10	1.45
Number of kernels per row	0.5620	4.22	0.8736	8.5	0.60	4.9
Number of kernel rows	0.3288	0.67	-10.8246	-38.4	0.82	4.09
Percent oil	-0.3812	-0.20	0.3214	0.20	0.75	0.37
100 grain weight	-0.7164	-1.36	0.1729	0.47	0.20	0.81
Grain yield kg/ha	0.8323	1734.4	0.8993	1652	0.850	1549

H = Broad sense heritability. GA = Genetic advance.

4. 2: Mean Squares Estimate for nine Agronomic Traits of Maize

The mean squares are presented in Tables 4.14, 4.15 and 4.16 for Samaru, Kadawa and the combined locations, respectively. At Samaru, estimates among the females' parent, for plant height, number of kernels per row and grain yield per hectare recorded highly significant differences, while number of leaves per plant, ear height and ear length showed significant differences (P = 0.05). For the males' parent, significant differences were recorded for number of kernels per row and grain yield per hectare. The male x female interaction indicated significant differences for percent oil and number of kernel rows, while grain yield per hectare showed highly significant difference. The result at Kadawa it indicated that the females' source of variation were significantly different for plant height, number of leaves per plant and ear length while number of kernels per row and grain yield showed highly significant differences (P = 0.01). For the males', number of kernels per row and grain yield showed highly significant differences (P = 0.01). The male x female interaction indicated highly significant difference only for number of kernels per row. The result for the combined analysis across locations indicated that the females' showed highly significant differences (P = 0.01) for plant height, number of leaves per plant, ear length, ear height, number of kernels per row and grain yield per hectare, while number of kernel rows showed significant difference (P = 0.05) level of probability. For the male parents, only number of kernels per row showed highly significant differences (P = 0.01), while the rest of the traits showed no significant differences. The male x female interaction indicated highly significant differences for ear length and number of kernels per row, while the rest of the traits showed no significant differences. For the male x locations interaction, no significant interactions was observe

except for grain yield per hectare which showed significant difference (P = 0.05) level of probability The female x location interaction indicated significant differences for ear height and number of kernel rows (P = 0.05) while the rest of the traits showed no significant differences. The male x female x location interaction records no significant difference.

4. 2.1: Components of Variance Male, Female and Male x female

The males', females' and male x female variance components for Samaru were presented in Table 4.17. The male variance component (σ^2_m) had positive values for number of leaves per plant, number of kernels per row and grain yield per hectare, while plant height, ear length, ear height, number of kernel rows, percent oil and 100 grain weight had negative values. The female' variance component (σ^2_f) showed negative values for number of kernels per row, ear height and grain yield, while plant height ear length, percent oil, number of kernel rows and 100 grain weight showed positive values. The male x female (σ^2_{mf}) variance estimates were positive for plant height, ear length, number of kernels per row, number of kernel rows, percent oil, and grain yield per hectare, while number of leaves per plant, ear length and 100 grain weight showed negative values. The female variance estimates (σ^2_f) had higher values for plant height, ear length number of kernel rows, number of kernel rows, percent oil and grain yield per hectare than the male (σ^2_m) variance estimates. The male x female (σ^2_{mf}) variance estimates had higher values for plant height, ear length, number of kernels per row, number of kernel rows percent oil, and 100 grain weight, while the male' variance (σ^2_m) had higher value for percent oil only over the male x female (σ^2_{mf}) variance and the female' (σ^2_f) variance components.

Table 4.14: Mean squares for design II experiment for nine agronomic traits of maize evaluated at Samaru in 2011

Source	df	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100GW	GYkg/ha
Rep	2	60.05	1.12	4.51	16.47	2.52	5.72	0.08	0.83	14547166.67**
Female	9	1029.48**	4.07*	5.14*	374.33*	43.08**	2.58	0.08	1.20	2566000.00**
Male	1	144.15	2.40	2.20	17.07	81.67*	1.67	0.0006	1.44	2242666.67*
Male x Female	9	472.00	1.18	8.04	78.33	30.56*	2.67	0.22*	1.73	940444.44**
Error	38	308.51	1.55	2.43	80.98	14.06	2.12	0.10	3.09	377692

**Significant at 1% level of probability. * Significant at 5% level of probability

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm NKR = Number of kernel rows. NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

Table 4.15: Mean squares for design II experiment for nine agronomic traits of maize evaluated at Kadawa in 2011

Source	df	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100GW	GYkg/ha
Rep	2	148.71	1.55	0.32	37.72	19.32	0.47	4.50	21.22	496166.67
Female	9	376.03*	3.59*	8.56*	147.46	91.15**	6.71	0.16	7.82	1838592.59**
Male	1	117.60	1.07	3.27	114.82	132.01**	3.75	0.0001	0.006	240666.67**
Male x Female	9	449.3	1.21	3.45	126.26	50.05**	3.94	0.12	0.51	232518.67
Error	38	153.12	1.5	3.97	122.51	10.59	2.046	0.15	4.66	250903.51

** Significant at 1% level of probability. * Significant at 5% level of probability

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm. NKR = Number of kernel rows. NK/R = Number of kernels per row PEROIL = Percent oil. 100 GW = One hundred grain weight. GYkg/ha = Grain yield per hectare

Table 4.16: Mean squares for design II experiment for nine agronomic traits of maize evaluated across locations in 2011

Source	df	PLTH	NOL	EL	EH	NK/R	NKR	%OIL	100GW	GYkg/ha
Location	1	343.41	0.133	5.85	4575.68**	106.42**	0.675	9.13**	9.19	456333.13
Rep(loc)	4	104.38	1.333	2.41	27.09	10.92	3.092	2.29	10.13	9342583.2**
Female	9	935.87**	7.54**	9.12**	300.50**	115.18**	4.82*	0.12	4.76	4005037.32**
Male	1	261.08	3.333	5.41	110.21	106.41**	5.208	0.0007	0.17	588000.20
Male x female	9	248.87	2.31	10.32**	69.93	67.100**	3.49	0.11	3.69	689111.31
Male x loc	1	0.68	0.13	0.05	21.68	3.01	0.21	0.00008	0.83	2817000.14*
Female x loc	9	469.65	0.11	4.58	221.29*	19.06	4.47*	0.12	4.66	434481.26
Male x female x loc	9	268.06	0.08	1.172	134.65	13.51	3.12	0.23	1.60	334407.23
Error	76	230.81	1.52	3.19	101.74	12.33	2.08	0.13	3.88	447113.22

** Significant at 1% level of probability. * Significant at 5% level of probability

The result for Kadawa is presented in Table 4.18. The female' variance estimates (σ^2_f) had positive values for all the traits except plant height. The males' variance estimates (σ^2_m) had positive values for number of kernels per row and grain yield per hectare while the rest of the traits showed negative values. The male x female variance estimates (σ^2_{mf}) had positive values for plant height, ear height, number of kernel rows and number of kernels per row, while the rest of the traits showed negative values. The females' variance estimates (σ^2_f) had higher values for all the traits except plant height, number of kernels per row over both the male and the male x female variance components. The male x female variance estimates (σ^2_{mf}) had higher values for number of kernel rows, number of kernels per row and plant height over the male' (σ^2_m) and the female' (σ^2_f) estimates variance. Result for the combined locations (Table 4.19) recorded that the females' variance (σ^2_f) estimates had positive values for all the traits except ear length that showed negative value. The males' variance estimates (σ^2_m) showed positive values for plant height, number of leaves per plant, ear height, number of kernels per row and number of kernel rows while ear length, percent oil, 100 grain weight and grain yield per hectare showed negative values. The male x female variance (σ^2_{mf}) showed negative values for plant height, percent oil and ear height while the rest of the traits showed positive values. The female x location (σ^2_{fl}) variance estimates showed positive values for all the traits except percent oil which showed negative value. The male x location variance estimates showed negative values for all the traits except grain yield per hectare and number of leaves per plant while the male x female x location showed negative values for number of leaves per plant, ear length, 100 grain weight and grain yield.

Table 4.17: Estimates of male, female and male x female variance for nine agronomic traits of Maize at Samaru in 2011

Trait	σ^2_m	σ^2_f	σ^2_{fm}
Plant height	-11.59	61.16	244.65
Number of leaves per plant	0.04	-0.12	-0.49
Ear length	-0.20	1.87	7.48
Ear height	-2.04	-0.883	-3.533
Number of kernels per row	1.70	5.5	22
Number of kernel rows	-0.077	0.6166	2.466
Percent oil	-0.01	0.04	0.16
100 grain weight	-0.01	-0.45	-1.81
Grain yield kg/ per hectare	43407.4	187584	750336

σ^2_m = variance male, σ^2_f = variance female, σ^2_{fm} = variance male x female

Table 4.18: Estimates of male, female and male x female variances for nine agronomic traits of maize at Kadawa in 2011

Traits	σ^2_m	σ^2_f	σ^2_{fm}
Plant height	-11.06	-12.21	98.73
Number of leaves per plant	-0.001	0.39	-0.13
Ear length	-0.006	0.8517	-0.17
Ear height	-0.38	3.53	1.25
Number of kernels per row	2.73	6.85	13.15
Number of kernel rows	-0.006	0.46	0.63
Percent oil	-0.004	0.006	-0.1
100 grain weight	-0.016	1.22	-1.38
Grain yield kg/ per hectare	271.6	267679	-6128.28

σ^2_m = variance male, $\sigma^2 f$ = variance female, $\sigma^2 fm$ = variance male x female

Table 4.19: Estimates of male', female', and male x female, male' x e, female' x e and m x f x e variances for nine agronomic traits of maize across locations in 2011

Traits	σ^2_m	σ^2_{ml}	σ^2_f	σ^2_{fl}	σ^2_{fm}	σ^2_{fml}
Plant height	0.2035	-13.3690	57.25	33.5983	-3.1983	12.4166
Number of leaves per plant	0.0171	0.0025	0.4358	0.0050	0.3716	-0.48
Ear length	-0.08183	-0.0561	-0.1	0.5680	1.5246	-0.6727
Ear height	0.6713	-5.6485	19.2141	14.44	-10.7867	10.97
Number of kernels per row	0.6552	-0.525	4.0066	0.92	8.9316	0.3933
Number of kernel rows	0.0286	-01455	0.1108	0.225	0.0616	0.3466
Percent oil	-0.00182	-0.0115	0.0008	-0.01833	-0.02	0.0333
100 grain weight	-0.0587	-0.0385	0.0892	0.51	0.3483	-0.76
Grain yield kg/ per hectare	-1685.19	124129.7	276327.2	66716	59117	-37568.7

σ^2_m = variance male, σ^2ml variance male x location, σ^2f = variance female, σ^2fl = variance female x location , σ^2fm = variance male x female σ^2fml = variance male x female x location.

4.2.2: Additive and Dominance Gene Actions

The estimates for additive (σ^2_A) and dominance genetic variances (σ^2_D) are presented in Tables 4.20, 4.21 and 4.22, for Samaru, Kadawa and across locations. Result for Samaru indicated that the estimate for males' additive gene action (σ^2_{Am}) showed positive values for number of leaves per plant, number of kernels per row and grain yield per hectare. Plant height, ear length, ear height, number of kernel rows, percent oil and 100 grain weight showed negative values. The females' additive gene action (σ^2_{Af}) showed positive values for plant height, ear length number of kernels per row, number of kernel rows, percent oil and grain yield per hectare, while ear height, number of leaves per plant and 100 grain weight showed negative values. The male x female genetic variance (σ^2_{Dmf}) indicated plant height, ear length, number of kernels per row, number of leaves per plant, and grain yield per hectare had positive values, while ear length, number of kernel rows, percent oil and 100 grain weight showed negative values. The females' additive genetic variance (σ^2_{Af}) had higher values for plant height, ear height, ear length, number of kernels per row, number of kernel rows, percent oil and grain yield per hectare compared to the males' additive genetic variance (σ^2 Am). The male x female dominance genetic variance (σ^2 Dmf) had higher values for plant height, number of leaves per plant, ear height and grain yield per hectare relative to the males' and the females' additive genetic variances (σ^2A), while the males' additive genetic variance (σ^2Am) had higher value for percent oil than the females' additive genetic variance and the male x female dominance genetic variance. Result for Kadawa indicated females' additive genetic variance showed positive values for all the traits except plant height, while the males' additive genetic variance (σ^2 Am) showed negative values for plant height, number of leaves per plant, ear

length, ear height, number of kernel rows, percent oil and 100 grain weight but positive values for number of kernels per row and grain yield per hectare. The male x female dominance genetic variance (σ^2 Dmf) showed positive values for plant height ear height, number of kernel rows and number of kernels per row, while the rest of the traits showed negative values. The females' additive genetic variance had higher values for all the traits except plant height, relative to the males' additive genetic variance and the male x female dominance genetic variance. The male x female dominance genetic variance (σ^2 Dmf), had higher values for plant height, number of kernels per row, number of kernel rows over the males' additive genetic variance (σ^2 Am). Result for combined locations which, showed that the females' additive genetic variance ($\sigma^2 A_f$) had higher values for plant height, number of leaves per plant, ear height, number of kernel rows, percent oil, and grain yield per hectare than the males' additive genetic variance (σ^2 Am) and the male x female dominance genetic variance (σ^2 Dmf). The male x female dominance genetic variance (σ^2 Dmf) had greater values for ear length, number of kernels per row, and 100 grain weight than the males' and the females' additive genetic variances ($\sigma^2 A$). Additive male x location (σ^2 Aml) showed positive values for number of leaves per plant and grain yield per hectare but negative values for the rest of the traits. The females' x location (σ^2 A_{fl}) additive genetic variance showed positive values for all the traits except percent oil which indicated negative value. The dominance male x female x location (σ^2 Dmfl) showed positive interaction with environment for plant height, ear height, number of kernel rows, number of kernels per row and percent oil, while number of leaves per plant, ear length, 100 grain weight and grain yield showed negative interaction with environment.

Table 4.20: Additive and dominance gene actions for nine agronomic traits of maize at Samaru in 2011

Traits	σ^2_{Am}	σ^2_{Af}	σ^2_{Dmf}
Plant height	-46.38	244.653	358.32
Number of leaves per plant	0.16266	-0.4933	1.9266
Ear length	-0.8053	7.48	-1.933
Ear height	-8.168	-3.533	197.33
Number of kernels per row	6.841	22	8.3466
Number of kernel rows	-0.3066	2.466	-0.9266
Percent oil	-0.02925	0.16	-0.0933
100 grain weight	-0.0386	-1.8133	-0.3533
Grain yield kg/ ha	173629.6	750336	1083704

σ^2_{Am} = variance additive males, σ^2_{Af} = variance additive female, σ^2_{Dmf} = variance dominance male x female

Table 4.21: Estimate of additive and dominance gene action for nine agronomic traits of maize at Kadawa in 2011

Traits	σ^2_{Am}	σ^2_{Af}	σ^2_{Dfm}
Plant height	-44.85	-48.85	394.90
Number of leaves per plant	-0.019	1.58	-0.52
Ear length	-0.02	3.41	-0.693
Ear height	-1.53	14.13	5
Number of kernels per row	10.93	27.4	52.61
Number of kernel rows	-0.03	1.85	2.52
Percent oil	-0.01	0.03	-0.04
100 grain weight	-0.06	4.87	-5.53
Grain yield kg/ ha	1086.4	1070716	-24513

σ^2_{Am} = variance additive males, σ^2_{Af} = variance additive female, σ^2_{Dmf} = variance dominance male x female

Table 4. 22: Estimates of additive and dominance variance, and their interactions with environment for nine agronomic traits of maize across locations in 2011

Traits	$\sigma^2_{A\,m}$	σ^2_{Aml}	σ^2_{Af}	σ^2_{Afl}	σ^2_{Dfm}	σ^2_{Dfml}
Plant height	0.81	-53.48	229	134.39	-12.79	49.66
Number of leaves per plant	0.06	0.01	1.743	0.02	1.48	-1.92
Ear length	-0.32	-0.22	-0.4	2.27	6.09	-2.69
Ear height	2.68	-22.59	76.85	57.76	-43.15	43.88
Number of kernels per row	2.62	-2.1	16.03	3.7	35.73	1.57
Number of kernel rows	0.11	-0.58	0.44	0.9	0.25	1.38
Percent oil	-0.007	-0.05	0.003	-0.07	-0.08	0.13
100 grain weight	-0.23	-0.15	0.35	2.04	1.39	-3.04
Grain yield kg/ ha	-0.6740.7	496518.6	1176327.2	66716	124129.7	-150275

σ^2 Am = variance additive males, σ^2 Af = variance additive female, σ^2 Dmf = variance dominance male x female

σ^2 Aml = variance additive males x location, σ^2 Afl = variance additive females x location, σ^2 Dmfl = variance dominance male x female x location

4. 2. 3 Narrow Sense Heritability Estimates

Narrow sense heritability estimates are presented in Table 4.23 for Samaru, Kadawa and the combined locations. Result for Samaru indicated plant height, number of leaves per plant, ear length, ear height, number of kernels per row, number of kernel rows, percent oil and grain yield per hectare have high positive narrow sense heritability estimates (1.547, 0.8052, 1.498, 1.469, 0.869, 1.759, 1.33), 0.8470, respectively), while 100 grain weight indicated a negative narrow sense heritability estimate (-0.035).

Result for Kadawa indicated plant height, ear length, ear height and number of kernel rows recorded negative narrow sense heritability estimates (-120.181, -0.6154, -0.4987 and -0.100, respectively) while number of leaves per plant, number of kernels per row, percent oil, 100 grain weight and grain yield per hectare recorded positive narrow sense heritability estimates (0.7272, 0.6606, 1.0667, 0.1445 and 0.1552 respectively).

Result for the combined locations indicated plant height, ear length, ear height, number of kernel rows and grain yield per hectare had negative narrow sense heritability estimates (-0.039, -3.6792, -0.2972, -2.2360 and -0.0254 respectively), while number of leaves per plant, number of kernels per row, percent oil and 100 grain weight indicated positive narrow sense heritability estimates (0.4510, 0.4829, 0.2475, 0.9037), respectively.

Table 4.23: Narrow sense heritability estimates for Samaru, Kadawa and across locations

Traits	Samaru	Kadawa	Combined locations
Plant height	1.54	-120.18	-0.039
Number of leaves per plant	0.8052	0.727	0.451
Ear length	1.498	-0.6154	-3. 679
Ear height	1.469	-0.498	-0. 297
Number of kernels per row	0.869	0.661	0.483
Number of kernel rows	1.759	-0.0858	-2.236
Percent oil	1.33	1.066	0.248
100 grain weight	-0.035	0.144	0.904
Grain yield kg/ ha	0.8470	0.155	-0.025

4. 3: Heterosis

Heterosis results are reported in Tables 4.24, 4.25 and 4.26 for Samaru, Kadawa and the combined locations. For Samaru (Table 4.24), oil content recorded that the entire crosses did not record any significant positive heterosis. For number of leaves per plant, five crosses recorded highly significant positive mid parent heterosis. The crosses Sammaz 18 x Sweet corn yellow and Sammaz 27 x Sweet corn white recorded highly significant positive high parent heterosis. For number of kernels per row, the crosses Sammaz 27 x Sweet corn yellow, and Sammaz 37 x Sweet corn yellow recorded highly significant positive mid parent heterosis. The cross Ex- Yola DT x Sweet corn white recorded highly significant positive high parent heterosis. For number of kernel rows, seventeen crosses recorded highly significant positive mid parent heterosis. Nine crosses recorded highly significant positive high parent heterosis. For ear height, the crosses Sammaz 13 x Sweet corn white and Sammaz 13 x Sweet corn yellow recorded highly significant positive mid parent heterosis. The cross Sammaz 13 x Sweet corn yellow recorded highly significant positive high parent heterosis. For Ear length, the crosses Ex Yola DT x Sweet corn white and Oba super 2 x Sweet corn yellow recorded highly significant positive mid parent heterosis. For 100 grain weight, the crosses Sammaz 29 x Sweet corn yellow, Sammaz 20 x Sweet corn white, Ex- Yola DT x Sweet corn white, Ex- Yola DT x Sweet corn yellow, Sammaz 13 x Sweet corn yellow and Sammaz 18 x Sweet corn yellow recorded highly significant positive mid parent heterosis. The crosses Sammaz 29 x Sweet corn yellow, Sammaz 20 x Sweet corn white, Sammaz 13 x Sweet corn yellow and Sammaz 18 x Sweet corn yellow recorded highly significant positive high parent heterosis.

Result for Kadawa is presented in Table 4.25. Percent oil recorded that the entire crosses did not record any significant positive heterosis. For number of leaves per plant, the crosses

Sammaz 38 x Sweet corn yellow, SDM2 x Sweet corn yellow and Sammaz 27 x Sweet corn yellow recorded highly significant positive mid parent heterosis. The cross Sammaz 18 x Sweet corn yellow recorded highly significant positive high parent heterosis. For number of kernels per row, the crosses Ex Yola DT x Sweet corn white and Sammaz 37 x Sweet corn yellow recorded highly significant positive mid parent heterosis. For number of kernel rows, fourteen crosses recorded highly significant positive mid parent heterosis. Five crosses recorded highly significant positive high parent heterosis. For ear height, the crosses Sammaz 29 x Sweet corn white, Sammaz 29 x Sweet corn yellow, Ex Yola Dt x Sweet corn white and Ex- Yola DT x Sweet corn yellow recorded highly significant positive mid parent heterosis. For ear length, the crosses Sammaz 27 x Sweet corn white, Sammaz 27 x Sweet corn yellow, Ex Yola DT x Sweet corn white and Sammaz 13 x Sweet corn white recorded highly significant positive mid parent heterosis. The crosses Sammaz 27 x Sweet corn white, Ex- Yola DT x Sweet corn white and Sammaz 13 x Sweet corn white recorded highly significant positive high parent heterosis. For 100 grain weight, the crosses Sammaz 29 x Sweet corn white, Sammaz 20 x Sweet corn white, Ex -Yola Dt x Sweet corn white, Oba super 2 x Sweet corn white, Sammaz 37 x Sweet corn white, Sammaz 37 x Sweet corn yellow and Sammaz 13 x Sweet corn white recorded highly significant positive mid parent heterosis.

Result for the combined locations is presented in Table 4.26. For Percent oil, plant height and grain yield per hectare, showed that the entire crosses did not record any significant heterosis. For number of leaves per plant, the crosses Sammaz 20 x Sweet corn yellow, Sammaz 27 x Sweet corn white and Sammaz 27 x Sweet corn yellow, recorded highly significant positive mid parent heterosis. The crosses Sammaz 20 x Sweet corn yellow, Sammaz 27 x Sweet corn white and Sammaz 27 x Sweet corn yellow recorded highly significant positive high parent

heterosis. For number of kernels per row, four crosses recorded highly significant positive mid parent heterosis. The crosses, Sammaz 37 x Sweet corn yellow and Sammaz 13 x Sweet corn yellow recorded significant positive high parent heterosis. For number of kernel rows, sixteen crosses recorded highly significant positive mid parent heterosis. The crosses Sammaz 29 x Sweet corn yellow, Oba super 2 x Sweet corn white and Sammaz 37 x Sweet corn yellow recorded highly significant positive high parent heterosis. For ear height, the cross Sammaz 13 x Sweet corn yellow, recorded highly significant positive mid parent heterosis. For ear length, the crosses Sammaz 20 x Sweet corn yellow and Ex- Yola DT x Sweet corn white recorded highly significant positive mid parent heterosis. For 100 grain weight, the crosses Sammaz 29 x Sweet corn white and Oba super 2 x Sweet corn white recorded highly significant positive mid parent heterosis.

Table 4.24: Mid parent heterosis (MPH) and high parent heterosis (HPH) expressed as percent for nine agronomic traits of maize evaluated at Samaru in 2011

Character	Heterosis	Crosses									
		Sammaz 29 x		*Sammaz 36 x*		*SDM2 x*		*Sammaz 20 x*		*Sammaz 27 x*	
		s.c.w	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*
PLTH cm	MPH	1. 8	-12.5	18.4	12.5	-20.6	-8.5	-12.9	-18.7	5.0	-9.98
	HPH	1. 6	-21. 5	16.2	-0.43	-32.0	-13.3	-14.9	-25.3	0.49	-15.5
NOL	MPH	-5.1**	-7.3**	-3.8**	-6.0**	7. 32**	6. 9**	-1. 33	-6.3**	11.11**	10.53**
	HPH	-9.8**	-7 **	-9.5**	-7.1**	-2. 2	2. 2	-2.6*	-9.8**	8.11**	2.4*
NK/R	MPH	8.6*	-2.6	2.4	-0.9	-9.6*	-4.8	-18.5**	-7.1	10.6*	19.2**
	HPH	1.0	-12.8*	0.0	-2.8	-11.0*	-10.1*	-23**	-16**	-1.0	2.7
NKR	MPH	12.6**	17.3**	11.1**	7. 9**	5.7**	2.6*	26.0**	9.1**	11.8**	11.1**
	HPH	2.56	12.8	0.0	2.5	-5.0**	-2. 5	12.2**	2.4	5.6**	11.1**
EH cm	MPH	-14.9	5.9	-13.8	1.7	-12.1	20.9*	-21.7*	0.34	-15.5	14.6
	HPH	-27.6*	5. 2	-22.4*	-4.6	-24.5*	19.6	-28.7*	-6.9	-31.8**	7.4
EL cm	MPH	-5.9**	-14.2**	-10.2**	-18.8**	-5.1**	-13.6**	-11**	8. 5*	-25.0**	-17.7**
	HPH	-14**	-22**	-21**	-29**	-16.7**	-24**	-21**	-4.4*	-30**	-23.9**
100GW	MPH	0.17	13.2**	-1.7	-0.6	-6.3**	-2.9**	97.3**	-3.0**	-3.9**	-4.25**
	HPH	-4.9**	13.1**	-3.56**	-3.7**	-8.1**	-5.9**	91.8**	-5.3**	-5.7**	-7.4**
%OIL	MPH	-5.8**	-11.5**	-11.7**	-4.8**	-16.73**	-4.3**	-12.3**	-7.1**	-10.9**	-8.0**
	HPH	-17.2**	-20.1**	-22.6**	-15**	-26.1**	-14.2**	-23**	-16**	-21.9**	-17.8**
GY kg/ha	MPH	42.9	62.9	69.5	111	164	135	23	11.1	119	213
	HPH	-11.7	-5.0	0.0	18.9	54.9	31.7	-32.2	-40.6	52.8	100

MPH = mid parent heterosis, HPH = high parent heterosis
PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm NKR = Number of kernel rows. NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

Table 4.24: Mid parent heterosis (MPH) and high parent heterosis (HPH) expressed as percent for nine agronomic traits of maize evaluated at Samaru in 2011

Character	Heterosis	Crosses									
		Ex Yola DT		*Oba super 2 x*		*Sammaz 37 x*		*Sammaz 13 x*		*Sammaz 18 x*	
		s.c.w	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*
PLTH cm	MPH	39.0	0.48	32.4	14.5	2.6	-8.99	22.3	-3.35	19.5	-6.4
	HPH	38.3	-10.0	17.2	-7.45	-3.94	-12.7	10.90	-20.21	11.2	-6.4
NOL	MPH	-10**	-2. 4*	1. 2	-12.9**	-8.6**	-15 **	0.00	-7.1**	3. 90*	8.6**
	HPH	-16**	-4.7**	-6.8**	-15.9**	-15.9**	-18.2**	-6.96**	-9.3**	0.0	7. 3**
NK/R	MPH	37.4**	-.3.7	-1.1	-7.5	-2.7	18.8**	-6.0	4.4	-6.0	-16**
	HPH	25.0**	-16**	-6.0	-16.6**	-8.0	7. 3	-7.0	-0.92	-12.8	-18.8**
NKR	MPH	8.1**	-2.6*	29.4**	11.1**	0.0	21.1**	12.3**	14.3**	11.8**	8.3**
	HPH	-4.8**	-9.5**	22.2**	11.1**	-10**	15.0**	0.0	7. 3**	5. 6**	8.33**
EH cm	MPH	-2.6	6.8	-21.8*	13.4	-27.9**	-13.8	32.5**	56.0**	17. 2	1.7
	HPH	-10.9	-1.3	-33.9**	12.6	-37.5**	-15.6	7.3	47.4**	6.8	-5.7
EL cm	MPH	15.5**	0. 51	-23.3**	11.1**	-7.1**	-13.6**	-15.4**	-15.8**	-6.7**	-14.7**
	HPH	0.0	-13.3**	-29.5**	-18.5**	-17.7**	-23.9**	-21.4**	-22.2**	-12.5**	-20.3**
100GW	MPH	4.61**	4.25**	0.25	-2.4*	-1.4	-1.8	-7.6**	7.0**	0.7	9.8**
	HPH	0.9	2.6*	-2.1	-5.1**	-1.5	-6.6**	-10.4**	4.8**	-2.6*	6.4**
%OIL	MPH	-16**	-6.6**	-5.9**	-2.8**	1.2	-11.9**	-21.7**	-7.7**	-5.7**	-14.6**
	HPH	-24.6**	-14.2**	-18.4**	-14.3**	-13.7**	-23.6**	-32.2**	-18.6**	-16.4**	-22.8**
GY kg/ha	MPH	30.4	-11.4	149	109	76	46	102	102	163	49.4
	HPH	-27.7	-52.3	45.8	16.9	5.7	-16.7	18.3	13.4	55.8	15.6

MPH = mid parent heterosis, HPH = high parent heterosis
PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm NKR = Number of kernel rows. NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

Table 4.25: Mid parent heterosis (MPH) and high parent heterosis (HPH) expressed as percent for nine agronomic traits of maize evaluated at Kadawa in 2011

Character	Heterosis	crosses									
		Sammaz 29		*Sammaz 36*		*SDM2*		*Sammaz 20*		*Sammaz 27*	
		s.c.w	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*
PLTH cm	MPH	6.1	7.1	8.3	12.0	12.1	6.5	0.6	19.1	12.1	19.6
	HPH	0.47	5.3	8.0	8.0	10.5	1.14	-6.4	15.0	4.9	16.2
NOL	MPH	-8.4**	-1.2	-7.2**	-4.9**	-1.1	3.4**	-10.8**	-6.2**	1. 27	9.1**
	HPH	-11.6**	-2.4	-9. 3**	-4.8**	-4.4**	-2.2	-13.9**	-7.3**	-6.9**	2.4
NKP	MPH	-23.0**	2.4	15.9*	10.5	-28.1**	-10.9**	-26.6**	-7.3*	-3.0	4.8
	HPH	-31.8*	-11.2	2.7	-4.3	-41.8**	-29**	-33.6**	-18**	-11.2	-6.9
NKR	MPH	10.1**	28.4**	1. 3	17.81**	21.7**	25.4**	-2.86	20.6**	28.1**	32.3**
	HPH	-7.3**	4. 9*	-19.2**	-8.6**	2.4	2.4	-19.1**	-2.4	13.9**	13.9**
EH cm	MPH	30.2**	28.6**	15.1	-9.9	-10.9	14.9	5.11	-6.9	6.1	4.7
	HPH	7.6	7. 3	11.3	-13.8	-20.1	2.2	I.6	-8.9	0.0	-2.4
EL cm	MPH	-3. 2*	-9.3**	-5.2**	-10.9**	-12.5**	-12**	-9.1**	0.0	19.6**	8. 3**
	HPH	- 4.2*	-12**	-9**	-11.8**	-16**	-12**	-13**	-8.0**	19.6**	4.0*
100GW	MPH	9.5**	-9.4**	-3.5*	-5.2**	-3.0	-0.08	9.2**	0.08	2. 3	2. 2
	HPH	1. 2	-11.5	-8.9	-5.4	-10	-2.9	1.9	-1.2	0.18	-1.5
%OIL	MPH	-4.8**	-7.2**	-24.2**	-11.6**	-17.1**	-18.6**	-12.8**	-18.3**	-8.4**	-18.9**
	HPH	-15.7**	-16.9**	-32.7**	-20.2**	-23.6**	-24.2**	-19.7**	-23.9**	-18.9**	-27.4**
GY kg/ha	MPH	66.4	99.7	61.9	104	123.3	142	38.9	27.8	77.6	77.8
	HPH	-6.158	10.7	-11.4	10.2	21.7	30.4	-25	-31.7	1.7	0.0

MPH = mid parent heterosis, HPH = high parent heterosis
PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm. NKR = Number of kernel rows.
NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

Table 4.25: Mid parent heterosis (MPH) and high parent heterosis (HPH) expressed as percent for nine agronomical traits of maize evaluated at Kadawa in 2011

Character	Heterosis	Crosses									
		Ex Yola DT		*Oba super 2*		*Sammaz 37*		*Sammaz 13*		*Sammaz 18*	
		s.c.w	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*
PLTH	MPH	11.7	18.9	0.48	0.5	7.6	14.1	7.4	4.8	-3.7	-5.3
	HPH	2.4	12.9	-1.4	-1.5	-1.9	7.9	-1.4	-0.25	-6.8	-11.7
NOL	MPH	-13.9**	-2.4*	-5.8**	-13**	-14.9**	-20**	-4.8**	-4.8**	-6.0**	8.6**
	HPH	-13.9**	-4.7**	-6.8**	-15.9**	-15.9**	-22.7**	-6.9**	-4.8**	-9.3**	7. 3**
NKP	MPH	18.6**	-6.0	-2. 3	-19.8**	4.8	16.0**	-22.5**	4. 9	-8.3	-7.1
	HPH	4.5	-18.9**	-10.9	-28.5**	-10.9	-3.4	-30.9**	-8.6	-20	-21 **
NKR	MPH	-10**	-5.3*	27.3**	15.6**	35.3**	21.2**	27.3**	15.6**	1.4	4.4*
	HPH	-30**	-28**	10.5**	-2.6	15**	0.0	10.5**	-2.6	-16.3**	-16.3**
EH	MPH	35.3**	30.4**	-7.5	-15.3	13.3	-6.9	21.7*	20.7*	-6.4	3. 5
	HPH	11.5	8.4	-14.4	-22.4	4. 9	-12.9	10.9	11.2	-12.1	-1.7
EL	MPH	28.8**	0.0	-5.2**	-4.9**	2. 2	-4.6**	12.6**	-3.3*	3. 3*	-5.6**
	HPH	26.1**	-6.0*	-9.8**	-5.8**	0.0	-10**	6. 5**	-12**	2. 2	-10**
100GW	MPH	20.2**	-7.9**	17.8**	0.8	7.6**	11.3**	6.4**	0.3	-5.3**	-9.5**
	HPH	8.9	-11.9	16.7	-3.9	3. 9	9.3	3.8	-2.9	-13.0	-12.3
%OIL	MPH	-10.4**	-11**	-19.8**	-18.7**	-15.9**	-3.1**	-12.6**	-15.9**	-9.2**	-2.6**
	HPH	-22.0**	-21.7**	-28.3**	-26.6**	-25.2**	-12.9**	-21.3**	-23.4**	-18.9**	-12**
GY kg/ha	MPH	33	7.4	13.0	30.9	63.5	106	107	114	73.9	65.4
	HPH	-28.5	-42.6	-40.0	-31.1	-9.8	12.3	13.9	16.3	-4.6	-10.5

MPH = mid parent heterosis, HPH = high parent heterosis
PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear height, cm. EH = ear height, cm. NKR = Number of kernel rows.
NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

Table 4.26: Mid parent heterosis (MPH) and high parent heterosis (HPH) expressed as percent for nine agronomic traits of maize across locations evaluated in 2011

character	Heterosis	crosses									
		Sammaz 29		*Sammsz 36*		*SDM2*		*Sammaz 20*		*Sammaz 27*	
		s.c.w	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*
PLTH	MPH	6. 37	-1.6	17.9	14.9	5. 33	8. 5	-7.2	-9.67	12.7	1.86
	HPH	5.81	-6.2	16.4	10.2	-0.71	7.8	-11.6	-9.94	10.6	-1.68
NOL	MPH	-1.2**	-4. 3**	-9.7**	-7.8**	-11 **	-9.8**	-0. 6	10**	15.7**	18.9**
	HPH	-1.2**	-4.9**	-10.8**	-8.4**	-15.4**	-14**	-2. 5**	7. 3**	8.6**	10. 9**
NK/R	MPH	-22.7**	-0.98	-4.5	5.0	-8.4	0. 26	-19.3**	1.74	-5.6	10.6**
	HPH	-26.9**	-5.1	-12.8**	-2.8	-18.3**	-9.4**	-24.7**	-3.7	-19.2**	-4.2
NKR	MPH	13**	24.3**	6.1	11.4**	13.5**	11.9**	11.9**	17.2**	19.7**	16.4**
	HPH	0.0	11.5**	-10	-4.6	-1.2	-1.23	-3.6	2.41	9.7*	8. 3*
EH	MPH	2.45	12.3	1. 2	-4.8	-18. 2	8. 4	-8. 3	-0.47	-4.53	7. 3
	HPH	-10.4	6. 4	-2.1	-9.7	-18.7	-1.0	-13.9	-2.74	-9.9	4. 2
EL	MPH	-6.7**	-11.8**	-4.6**	-14.8**	-16.9**	-12.8**	-10.2**	4.4**	3.0*	-5.2**
	HPH	-10.9**	-17.4**	-8.8**	-20**	-20.6**	-18.3**	-17.7**	-6.1**	-0. 98	-10.8**
100GW	MPH	1.74	4.14**	3. 3*	-3	0.62	-2.15	-0.76	-1.42	-2.14	-0.98
	HPH	0. 25	2. 9	1.4	-4.5**	-2.6	-5.0	-2.84	-3.21	-2.47	-1.02
%OIL	MPH	-5.39**	-9.51**	-18.9**	-8.94**	-15.7**	-12.0**	-12.2**	-12.3**	-11.4**	-14.8**
	HPH	-16.48**	-18.9**	-27.1**	-17.1**	-25.3**	-20.8**	-21.3**	-20.1**	-20.5**	-22.4**
GY kg/ha	MPH	69.84	99.28	71.08	112.1	143.6	130.2	30.0	20.8	77.2	147.
	HPH	0.00	11.20	-2.52	15.72	37.36	24.7	-29.2	-36.0	6. 3	39.6

MPH = mid parent heterosis, HPH = high parent heterosis
PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm NKR = Number of kernel rows.
NK/R = Number of kernels per row PEROIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

Table 4.26: Mid parent heterosis (MPH) and high parent heterosis (HPH) expressed as percent for nine agronomic traits of maize across locations evaluated in 2011

character	Heterosis									
		Ex Yola DT		*Oba super 2*		*Sammaz 37*		*Sammaz 13*		*Sammaz 18*	
		s.c.w	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*	*s.c.w*	*s.c.y*
PLTH	MPH	25.16	2.48	10.68	5.12	8.7	1.5	14.7	0.4	10.8	0.64
	HPH	22.91	-1.08	6.83	3.23	8.4	-3.9	11.4	-7	3.0	-2.5
NOL	MPH	-18**	-12**	-7.6**	-11.8**	-5.3**	-1.18**	-10**	-15**	-9.3**	1. 2
	HPH	-4.6**	-14**	-11**	-15**	-9.1**	-4.6**	-11.9**	-15.5**	-9.8**	0.00
NKP	MPH	12.9**	3. 34	-4.4	-7.0*	0. 5	15.3**	-7.81*	16**	1. 2	-14.6**
	HPH	1.83	-5.6	-14.6**	-15.9**	-8.7*	6.1*	-16.4**	6. 6*	-5.5	-19.3**
NKR	MPH	-0.0	-5. 2	28.4**	13.2**	17.1**	33.8**	17.7**	13.3**	6. 5*	14.9**
	HPH	-17.4	-20.7	16.2**	4.1	2. 5	18.7**	2.4	0.0	-6.3	2. 5
EH	MPH	8. 3	11.1	-14.0	-3.6	-7.7	-10.6	27.5*	37**	5. 5	2.69
	HPH	0.00	10.4	-17.1	-8. 4	-16.8	-12.5	9.0	26.8*	-2.4	1.89
EL	MPH	21.9**	-3.9**	-14.5**	-5.1**	-4.7**	-9.0**	1. 57	-9.9**	-5.1**	-9.2**
	HPH	11.8**	-13.6**	-16.2**	-8.9**	-11.8**	-17.4**	-4.9**	-17.4**	-8.8**	-14.6**
100GW	MPH	1.62	0.00	4.49**	0.04	-1.43	1.13	-3.32	3.78**	3.07*	0.74
	HPH	-1.76	-3.05	4.04*	-0.68	-3.31	-0.50	-3.69*	3.07	3.29*	-2.33
%OIL	MPH	-13.6**	-8.21**	-12.5**	-10.4**	-6.75**	-8.39**	-16.9**	-9.4**	-7.98**	-9.6**
	HPH	-23.4**	-17.4**	-23.1**	-20.2**	-19.1**	-19.3**	-27.1**	-19.3**	-17.6**	-9.6**
GY kg/ha	MPH	31.7	9. 2	51.2	40.3	68.9	67.2	92.4	109.	119.	49.6
	HPH	-28.1	-42.2	-17.6	-25.7	-3.3	-8.5	8.9	13.7	24.7	-18.5

MPH = mid parent heterosis, HPH = high parent heterosis
PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm NKR = Number of kernel rows.
NK/R = Number of kernels per row PEROIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

4:4: Genotypic and Phenotypic Correlations

The correlation values for Samaru were presented in Table 4.27. The result recorded highly positive significant genotypic and phenotypic correlations between plant heights with Ear height,(r = 0.455, r = 327), number of kernel rows with 100 grain weight (r = 0.589, r = 0.493), Ear height with ear length(r = 057, r = 0.372) and plant height with number of kernel rows (r = 0.535, r = 0.808) while correlations between Ear length with 100 grain weight (r = 0.5587, r = 0.2898) and Ear height with 100 grain weight (r = 0.996, r = 0.372) recorded highly significant positive genotypic and significant positive phenotypic correlation. Correlations between number of kernel rows with number of kernels per row (r = -0.364, r = -0.318), between number of kernel rows with number of leaves per plant = -0.396, r = -0.560) and between plant heights with number of kernel rows (r = -0.327, r = -0.726) recorded highly significant negative genotypic and phenotypic correlations.

Results for Kadawa were presented in Table 4.28. The result showed highly positive significant genotypic and phenotypic correlations between plant height with ear height (r = 0.815, r = 0.306), plant height with number of leaves per plant (r = 0.897, r = 0.907), grain yield per hectare with plant height (r = 0.880, r = 0.533) and percent oil with number of kernel rows (r = 0.447, r = 0.388). Highly negative significant genotypic and phenotypic correlations were observed between grain yield per hectare with ear length (r = -0.699, r = -0.617) and between grain yield per hectare with number of kernels per row (r = - 0.264, r = - 0.315).

The results for the combined data across locations were presented in Table 4.29. The result recorded highly positive significant genotypic and phenotypic correlations between ear length with 100 grain weight (r = 0.979, r = 0.455), number of kernels per row with 100 grain weight (r = 0.980, r = 0.857), plant height with 100 grain weight (r = 0.976, 0.779), plant height

with ear height (r = 0.439, r = 0.259)) and plant height with number of kernels per row (r = 0.535, r = 0.372) while highly significant positive genotypic and significant phenotypic correlations were observed between ear height with ear length(r = 0.517, r = 0.261) and number of kernels per row with ear length (r = 0.529, r = 0.313). Highly negative significant genotypic and phenotypic correlations were observed between grain yield per hectare with number of kernels per row (r = -0.467, r = -0.661), while highly negative significant genotypic and negative significant phenotypic correlations were observed between number of leaves per plant with ear length (r = -0.965, r = -0.274) and between number of kernel rows with ear length (r = -0.809, r = - 0.259). Significant negative genotypic and significant negative phenotypic correlations were observed between ear length with 100 grain weight (r = - 0.325, r = - 0.288).

Table 4.27: Genotypic and phenotypic correlation coefficients among nine agronomic characters of maize at Samaru in 2011

Characters		100 grain weight	Ear length	Ear height	No of kernels/row	Number of Leaves/ plant	No of kernel rows	Percent oil	Plant height	Grain yield kg/ha
100 grain weight	rg	1.000	0.559**	0.996**	0.410**	-0.897**	0.589**	0.130	0.943**	-0.054
	rp	1.000	0. 289*	0. 287*	0.141	-0.0936	0.493**	0.133	-0.006	0.188
Ear length	rg		1.000	0.575**	0.331**	-0.980**	-0.389**	0.144	0.536**	-0.214
	rp		1.000	0. 372**	0.178	0.4315**	-0.2263	-0.027	0.155	0.130
Ear height	rg			1.000	0.276*	-0.016	0.011	-0.989**	0.454**	0.481**
	rp			1.000	0. 237	0.454**	0.010	0.004	0.328**	0.006
No of kernels/row	rg				1.000	-0.331**	-0.364**	-0.164	0.535**	-0.119
	rp				1.000	-0.015	-0.317**	-0.623**	0.807**	-0.167
Number of Leaves	rg					1.000	-0.396**	0.073	-0.077	0.581**
	rp					1.000	-0.56**	-0.001	0.254	-0.022
No of kernel rows	rg						1.000	-0.277*	-0.327**	-0.139
	rp						1.000	-0.028	-0.726**	0.014
Percentage oil	rg							1.000	0.312**	-0.027
	rp							1.000	0.006	0.008
Plant height	rg								1.000	0.3971**
	rp								1.000	0.0036
Grain yield kg/ha										1.000
										1.000

* =significant at 5% level (0.262); ** =significant at 1% level (0.339); df = N-2= 58

Table 4.28: Genotypic and phenotypic correlation coefficients among nine agronomic characters of maize at Kadawa in 2011

Characters		100 grain weight	Ear length	Ear height	No of kernels /row	Number of Leaves/ plant	No of kernel rows	Percent oil	Plant height	Grain yield Kg/ha
100 grain weight	rg	1.000	0.293**	-0.227	-0.179	-0.228	-0.305**	-0.306**	0.739**	-0.384**
	rp	1.000	-0.0002	0.178	0.365**	-0.005	-0.050	-0.050	0.236	-0.198
Ear length	rg		1.000	0.862**	0.691**	-0.892**	-0.306**	-0.172	0.507**	-0.699**
	rp		1.000	0.076	0.022	-0.097	-0.011	-0.451**	-0.005	-0.617**
Ear height	rg			1.000	0.011	0.664**	-0.450**	-0.526**	0.813**	0.262*
	rp			1.000	0.066	0.116	0.007	0.864**	0.306**	-0.071
No of kernels /row.	rg				1.000	-0.542**	0.223	-0.064	-0.412**	-0.264**
	rp				1.000	-0.088	0.006	-0.625**	-0.116	-0.315**
Number of Leaves /plant.	rg					1.000	-0.422**	-0.141	0.897**	0.710**
	rp					1.000	-0.022	0.552**	0.907**	0.004
No of kernel rows.	rg						1.000	0.447**	-0.585**	0.185
	rp						1.000	0.387**	-0.039	0.062
Percentage oil.	rg							1.000	-0.401**	-0.230
	rp							1.000	-0.084	-0.084
Plant height.	rg								1.000	0.880**
	rp								1.000	0.533**
Grain yield Kg/ha.										1.000
										1.000

* =significant at 5% level (0.262); ** =significant at 1% level (0.339); df = N-2= 58

Table 4.29: Genotypic and phenotypic correlation coefficients among nine agronomic characters of maize across locations in 2011

Characters		100 grain weight	Ear length	Ear height	Number kernel/row	Number of Leaves/ plant	No of kernel rows	Percentage oil	Plant height	Grain yield Kg/ha
100 grain weight	rg	1.000	0.979**	-0.325*	0.980**	-0.631**	-0.459**	0.0463	0.976**	0.6284**
	rp	1.000	0.455**	-0.288*	0.857**	-0.023	-0.2357	-0.0690	0.779**	- 0.698**
Ear length	rg		1.000	0.516**	0.527**	-0.965**	-0.809**	-0.007	0.436**	-0.549**
	rp		1.000	0.261*	0.312*	-0.274*	-0.260*	0.006	0.126	-0.159
Ear height	rg			1.000	0.034	0.358**	-0.925**	-0.054	0.439**	0.336**
	rp			1.000	0.046	0.122	-0.228	-0.026	0.259*	-0.882**
No of kernels/row	rg				1.000	-0.602**	0.183	-0.009	0.535**	0.404**
	rp				1.000	0.017	0.130	0.067	0.371**	-0.177
Number of Leaves/ plant	rg					1.000	-0.916**	-0.0326	0.292*	-0.364**
	rp					1.000	0.176	0.175	-.007	-0.196
No of kernel rows	rg						1.000	-0.045	-0.894**	-0.467**
	rp						1.000	0.283*	-0.215	-0.661**
Percentage oil	rg							1.000	-0.451**	0.481**
	rp							1.000	0.052	-0.056
Plant height	rg								1.000	-0.780**
	rp								1.000	-0.136
Grain yield Kg/ha										1.000
										1.000

* =significant at 5% level (0.262); ** =significant at 1% level (0.339); df = N-2= 118

4. 5: Path Analysis

The path analysis result for Samaru is presented in Table 4.30. Plant height had positive direct effect toward oil content (1.5465), while the rest of the traits showed negative direct effects. There were positive indirect effects for number of leaves per plant through 100 grain weight (0.4519), 100 grain weight through plant height (1.4582), ear length through plant height (0.8289), ear height through plant height (0.7020), number of kernel rows through number of leaves per plant (0.1666), number of kernel rows through plant height (0.8280), number of leaves per plant through 100 grain weight (0.4009), number of kernel rows through 100 grain weight (0.2634), number of kernels per row through number of kernel rows (0.2675), and grain yield per hectare through plant height (0.6140).

The path analysis result for Kadawa is reported in Table 4.31. The result indicated that number of kernels per row (0.3626), ear height (0.4299) and 100 grain weight (0.2518), had direct positive effects toward oil content. The positive indirect effects were observed on ear length through ear height (0.3761), number of leaves per plant through ear length (0.2763), number of leaves per plant through ear height (0.2856), number of kernels per row through plant height (0.2724), plant height through 100 grain weight (0.1860), plant height through ear height (0.3502) and grain yield per hectare through ear length (0.2165).

Result for the combined locations is presented in Table 4.32. The result showed 100 grain weight (0.2104), ear height (0.1052), Plant height (0.1778) and grain yield per hectare (0.4016) had direct positive effects toward effects toward oil content. There were positive indirect effects for 100 grain weight through ear length (0.2374), through number

of leaves per plant (0.2891), through plant height (0.1773) and through grain yield per hectare (0.2524). Positive indirect effects were observed for ear length through 100 grain weight (0.2059), through number of leaves per plant (0.4421) and ear height (0.5438). There was a positive indirect effect of ear height through grain yield per hectare (0.1352). Positive indirect effect was observed for number of kernel rows through number of leaves per plant (0.2758). Positive indirect effects were observed for number of leaves per plant through ear length (0.2339) and through number of kernel rows (0.3747). Positive Indirect effects were observed for number of kernels per row through ear length (0.1961) and through number of leaves per plant (0.4196). Positive Indirect effect was observed on number of leaves per plant through 100 grain weight (0.2891).

Table 4.30: The direct (Diagonal) and indirect effects of different characters of maize toward oil content at Samaru in 2011

Yield attributes	100sw	EL	EH	NKR	NOL	NK/R	PLTH	GY kg/ha	Gen/cor
100Gw	**-0.44705**	-0.0326	-1.0786	-0.2565	0.4519	0.0388	1.4582	-0.00381	**0.1304**
EL	-0.2498	**-0.0584**	-0.6222	-0.2071	0.4932	-0.0258	0.8289	-0.01491	**0.1440**
EH	-0.4454	-0.0336	**-1.0824**	-0.1726	0.0080	0.0007	0.7029	0.0336	**-0.9887**
NKR	-0.1835	-0.0193	-0.2989	**-0.6248**	0.16663	-0.02412	0.8280	-0.0083	**-0.1644**
NOL	0.4009	0.0572	0.0172	0.2069	**-0. 5031**	0.0263	-0.1198	0.0041	**0.0735**
NK/R	0.2634	0.0227	-0.0113	0.2275	-0.1996	**-0.0663**	-0.5082	-0.0097	**-0.2766**
PLTH	-0.4216	-0.0313	-0.4919	-0.3345	0.0389	-0. 0218	**1. 5465**	0.0277	**0.3121**
GY kg/ha	0.02427	0.01256	-0.5213	0.07453	-0.2929	-0.0093	0.6140	**0.0697**	**-0.0278**

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm. NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

Table 4.31: The direct (Diagonal) and indirect effects of different characters of maize toward oil content at Kadawa in 2011

Yield attributes	100Gw	EL	EH	NKR	NOL	NK/R	PLTH	GY kg/ha	Gen/cor
100GW	**0. 2518**	-0.0908	-0.0977	0.0284	0.0215	-0.1105	-0.3443	0.0361	**-0.3055**
EL	0.0736	**-0.3098**	0.3761	-0.1095	-0.0842	-0.1109	-0.2363	0.0657	**-0.1723**
EH	-0.0572	-0.2670	**0.4299**	-0.0018	-0.01697	-0.1631	-0.3796	-0.0245	**-0.5264**
NKR	-0.0415	-0.2141	0.0051	**-0.1585**	0.0512	0.0808	0.1919	0.0247	**-0.0639**
NOL	-0.0573	0.2763	0.2856	0.0895	**-0.0945**	-0.1530	-0.4177	-0.0667	**-0.1414**
NK/R	-0.0768	0.0848	-0.1934	-0.0354	0.0398	**0.3626**	0.2724	-0.0174	**0.4467**
PLTH	0.1860	-0.1571	0.3502	0.0653	-0.0874	-0.2120	**-0.4659**	-0.0828	**-0.4010**
GY kg/ha	-0.0967	0.2165	0.1124	0.0417	-0.0671	0.0672	-0.4101	**-0.0940**	**-0.2303**

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm. EH = ear height, cm. NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. Gykg/ha = Grain yield per hectare

Table 4.32: The direct (Diagonal) and indirect effects of different characters of maize toward oil content across locations in 2011

Yield attributes	100GW	EL	EH	NKR	NOL	NK/R	PLTH	GY kg/ha	Gen/Cor
100GW	**0.2104**	0.2374	-0.03425	-0.6104	0.2891	0.00289	0.1736	0.2524	**0.0463**
EL	0.2059	**-0.2424**	0.5438	-0.3297	0.4421	0.0051	0.0777	-0.2205	**-0.0075**
EH	-0.0684	-0.1253	**0.1052**	-0.02117	-0.1641	0.00583	0.07814	0.1351	**-0.0549**
NKR	0.2062	-0.1284	0.0036	**-0.6226**	0.2758	-0.00115	0.09518	0.1622	**-0.0091**
NOL	-0.1327	0.2339	0.0377	0.3747	**-0.4581**	0.0057	0.0519	-0.1460	**-0.0327**
NKP	-0.0965	0.1961	-0.0937	-0.1139	0.4196	**-0.0063**	-0.1590	-0.1876	**-0.0451**
PLTH	0.2053	-0.1059	0.0462	-0.3332	-0.1337	0.0056	**0. 1778**	-0.3132	**-0.451**
GY kg/ha	0.1322	0.1331	0.03539	-0.2616	0.1666	0.0029	-0.1387	**0.4016**	**0.4815**

PLTH = Plant height, cm. NOL = Number of leaves per plant. EL = Ear length, cm.EH = ear height, cm. NKR = Number of kernel rows.

NK/R = Number of kernels per row %OIL = Percent oil. 100 GW = One hundred grain weight. GY = Grain yield per hectare

CHAPTER 5

5.1 Discussion

The analysis of variance at Samaru showed significant differences on plant height, number of kernels per row, ear height, ear length, number of leaves per plant and grain yield per hectare. At Kadawa it showed significant difference for Plant height, number of leaves per plant, number of kernels per row, ear height and grain yield per hectare, these result is indicating significant genetic variability within the mentioned traits in each location, thus genetic improvement can be achieve for the characters. For the across locations, the result recorded significant difference for all the traits except 100 grain weight; this showed that the mean differences in each location differ significantly from each other, the non-significant location differences observed on all the traits indicated that the entries were consistent in two locations. The findings of Masoud and Saleem (2009) differ with this finding where they reported highly significant difference for separate locations and across locations for all the traits including oil content. The findings of Oliveira *et al.* (2006) differ with this research finding where they obtained significant variability for oil content, also the findings of Saleem *et al.* (2008) differ with this finding where they obtained significant variability for oil content.

The mean values for the progenies for oil content for single location and across locations indicated lower mean values relative to the male parents; this finding showed that the genes responsible for oil content in the male parents are recessive and are not contributing positively in varietal crosses, the mean values for the progenies on grain yield per hectare, number of kernel rows, ear height, number of leaves per plant and plant height

were higher relative to the males and females parents at Samaru this shows that the genes controlling the characters have contributed significantly in the crosses, while at Kadawa the mean values for the progenies on grain yield per hectare, number of kernel rows, ear height and plant height were higher relative to the males and females parents, this also showed that the genes controlling the characters have contributed significantly in the crosses but for combined locations higher mean values for the progenies relative to their parent were recorded on grain yield per hectare, 100 grain weight and number of kernel rows.

Genotypic and Phenotypic coefficient of variations showed that all the traits recorded higher values for phenotypic coefficient of variation relative to genotypic coefficient of variation in both locations except for number of kernel rows and grain yield per hectare at Kadawa that showed lower values of phenotypic coefficient of variation relative to genotypic coefficient of variation. This finding showed that environment plays a greater role in the expression of the traits, suggesting for quantitative trait. Environmental factors likely affecting oil content in maize are light intensity, photoperiodism, soil nutrients such as nitrogen, phosphorus, potassium, sulphur and management practices (Jellum and Marion, 1966). Similar to this findings was reported by Rosulj *et al.* (2002), where they reported nearly similar values of genotypic and Phenotypic coefficient of variations for percent oil (9.3%, 9.35%) and grain yield per hectare (12.9%,13.4%) for different populations.

The variance components at Samaru showed that percent oil recorded negative estimates for the male parents; the female parents and the male x female recorded very low positive estimates. Estimates at Kadawa recorded negative estimate for male parents while, for females' parent and male x female recorded positive estimates, this showed that at Samaru and Kadawa, locations the male parents behave similar in performance, while the

females parent and the males x females, showed little differences among them in both locations. Across locations estimates, the females and males parent recorded negative interactions, this indicated similarities of parents' performance across locations. The negative estimates may be due to inadequate genetic model (genetic design), inadequate sampling (small sample) and inadequate experimental techniques (competition among progenies) (Hallauer and Miranda, 1981).

Broad sense heritability estimates for grain yield per hectare, number of kernels per row, plant height and number of leaves per plant, all indicated high broad sense heritability estimates of 0.8, 0.8, 0.6 and 0.5, respectively in both locations, with high genetic advances for both locations, this showed that their genotypic variances were relatively large which may be as a result of effect of major genes controlling the characters which could easily be inherited**.** At Samaru, characters like ear length and number of kernel rows, recorded higher broad sense heritability estimates than at Kadawa this is indicating better performance of these characters at Samaru location, while percent oil and 100 grain weight recorded negative estimates this indicated lower performance of these traits at the location, while at Kadawa all the traits recorded high estimates for broad sense heritability estimates except number of kernel rows and 100 grain weight that showed negative and low positive values, this means traits like number of kernels per row, plant height, grain yield per hectare, number of leaves per plant and ear height showed better performance in this location. Across location estimates indicated ear height, ear length and 100 grain weight recorded low broad sense heritability estimates, this means that the traits would behave similar across the locations. High broad sense heritability estimates indicated that selection will lead to fast genetic improvement of a trait i.e. by increasing the frequency of favorable

alleles by repeated mass selection or hybridization between selected genotypes having varying degrees of a trait. Similar work was reported by Zahid *et al.* (2004) where they found high broad sense heritability estimates for grain yield per hectare and plant height.

The results for general and specific combining ability estimates were reported in term of additive and dominance gene actions for the traits studied. The result for Samaru indicated that ear length; number of kernels per row, number of kernel rows and percent oil were controlled by additive gene action from female parents this shows that improvement could be achieved through selection. Similar to this finding, (Dudley, 1977) reported additive gene action as the main component influencing oil content in Maize. Similar to this finding (Miller and Brimhall., 1951) also reported that maternal effect is the major effect in the influence of oil content in Maize. Plant height, number of leaves per plant, ear height and grain yield per hectare were controlled by dominance gene action, while 100 grain weight was controlled by additive gene action from the male parents. Masoud and Saleem (2009) also reported additive gene action as the major component controlling oil content. For Kadawa, number of leaves per plant, ear length, ear height, 100 grain weight, percent oil and grain yield per hectare were controlled by additive gene action from the female parents this shows that improvement is possible through selection, while plant height, number of kernels per row and number of kernel rows were controlled by dominance gene action, this means improvement is possible through hybridization. For the combined locations additive gene action from the female parent had greater values on all the traits except ear length, number of kernels per row and 100 grain weight. This finding showed that additive genetic variances in the female parents were more important in controlling most of the traits studied. This finding differs with the work of Masoud *et al.,* (2009) where

they reported over dominance as the major gene action controlling most of the traits studied including oil content.

Narrow sense heritability estimates for Samaru showed high positive estimates for all the traits studied except 100 grain weight, (-0.035). For Kadawa all the traits studied indicated low narrow sense heritability estimates except number of leaves per plant, number of kernels per row and percent oil that indicated high estimates. For the combined locations, all the traits indicated low narrow sense heritability estimates except number of leaves per plant, number of kernels per row and 100 grain weight that indicated high estimates. Variation of narrow sense heritability estimates between locations indicated interaction between location and additive gene actions. From the study, high narrow sense heritability estimate indicates additive gene action was the major component of the inheritance of the traits studied; high narrow sense heritability estimates obtained is indicating importance of additive gene actions, improvement is possible through selection. High and positive narrow sense heritability estimate for oil content was also reported by Rosulj *et al.* (2002). Low narrow sense heritability estimates for 100 grain weight and high narrow sense heritability estimates for number of kernels per row, plant height was also reported by Wannous *et al.* (2010). Rafiq *et al,* (2010) found similar result with this study, where they obtained high narrow sense heritability estimates for grain yield per hectare, plant height, ear length and ear height. Similar finding was reported by Mahmood *et al,* (2004) where they obtained high narrow sense heritability estimates for plant height, ear length, number of kernels rows and number of kernels per row. Negative estimates obtained in all the locations and across locations indicated large error variance associated with the experiment which is greater than genotypic variance.

Heterosis for oil content indicated that the entire F_1 in both locations and across locations recorded negative values; this indicated that the genes responsible for oil content are not contributing positively to oil content in these varietal crosses; it is also indicating that the genes controlling oil content are recessive. This finding differs with the finding of Abou-Dief *et al*. (2012) where they found negative high parent heterosis and positive significant mid parent heterosis among their crosses of inbred lines for oil content. Similarly Drinic *et al.* (2012) finding differs with this study, where they obtained positive mid and high parent heterosis for oil content among their crosses. At Samaru crosses SDM2 x Sweet corn white and SDM2 x Sweet corn yellow recorded the highest values for oil content followed by Sammaz 36 x Sweet corn white and Sammaz 36 x Sweet corn yellow. At Kadawa crosses SDM2 x Sweet corn white and SDM2 x Sweet corn yellow, recorded the highest values for oil content among the progenies, while result across locations indicated Sammaz 36 x Sweet corn white and Sammaz 36 x Sweet corn yellow recorded the highest values, this indicated Sammaz 36 and SDM2 are the better potential female parents in this research.

Correlation results at Samaru did not record positive significant genotypic and phenotypic correlation between oil content with the entire traits studied, but at Kadawa, there were highly significant phenotypic correlations between oil content with number of kernels per row, and Significant phenotypic correlations between oil content with ear height and number of leaves per plant. The significant phenotypic correlation observed between oil content with number of leaves per plant, ear height and number of kernels per row indicated that the association between them is more of environmental than genotypic influence. Highly significant genotypic and significant phenotypic correlations between oil content with number of kernel rows indicate that selection of number of kernel rows could influence oil

content, while for across locations, there was significant phenotypic correlations between oil content with number of kernel rows selection of these traits could not be effective in influencing oil content because of absence of genotypic association. This result is in agreement with the work of Okporie and Oselebe (2007) where they found positive significant phenotypic correlation between oil content with ear height. Similar result was reported by Sreckov *et al.* (2011) where they found medium positive phenotypic correlation between oil content with ear height, number of leaves per plant and number of kernel rows. Wannous *et al.* (2010) also found similar result with this work where they obtained positive significant phenotypic correlation between plant heights with ear height.

Path analysis result for Samaru indicated that plant height had the highest direct positive contribution toward oil content followed by grain yield per hectare. The direct contributions of the other traits were all negative. The highest indirect contributions were registered for plant height through 100 grain weight, ear length, ear height, number of kernel rows, and grain yield per hectare. This showed that selection for plant height could contribute positively towards oil content in the population, because the result indicated significant genotypic correlation between plant height and oil content (0.3121). However, plant height also contributed negatively to oil content through number of kernels per row and number of leaves per plant. The number of leaves per plant, on the other hand contributed indirectly through 100 grain weight and ear length. Selection for oil content at Samaru should therefore consider plant height and number of leaves per plant as selection criteria. The indirect positive contribution of plant height and number of leaves per plant through ear length could not be effective because of insignificant genetic correlation between oil content with ear length (0.1304). Results from Kadawa indicated ear height, number of kernels per row and

100 grain weight had positive direct effect with oil content. Direct selection of 100 grain weight may not give a positive improvement because of the negative genotypic correlation (-0.3055) between oil content and 100 grain weight. Like wise direct selection of ear height toward oil content will not give a positive result, because of the significant negative genotypic correlation (-0.5264), between ear height and oil content. Direct selection of number of kernels per row will enhance a better oil content because of the significant positive genotypic correlation (0.4467) between numbers of kernel per row with oil content. Indirect selection of ear height through ear length will not improve oil content because of the negative genotypic correlation (-0.1723) between oil content with ear length. For the combined locations, grain yield per hectare has the highest positive direct contribution to oil content followed by 100 grain weight and ear height. Direct selection of grain yield per hectare could give a positive result on oil content because of the positive genotypic correlation (0.4815) between grain yield per hectare and oil content. Direct selection for 100 grain weight could not give good result, this is because of low positive genotypic correlation (0.0463) between 100 grain weight with oil content also direct selection of ear height will also not give positive result for oil content, because of the negative genotypic correlation (-0.0549) between ear height with oil content. Indirect selection of grain yield per hectare through ear length, number of leaves per plant and 100 grain weight could improve oil content because of the positive genotypic correlation between oil content and grain yield per hectare. Hosyan *et al*. (2012) reported direct positive effect of grain yield per hectare on oil content, which is similar to this research finding for the combined locations, but Karnataka (2012), reported negative direct effect of grain yield per hectare on oil content, which correspond to this research finding for Samaru and Kadawa locations.

CHAPTER 6

6.1: Summary

Maize cultivar often have low oil kernel content, to increase oil content in maize, efficient breeding programme have to be develop. To achieve this, certain objectives were considered and used in this research work and the result showed that variability were obtained on all the traits studied except oil content at all the locations, high narrow sense heritability estimates were obtained including for the oil content, positive significant correlations were also obtained between oil content with some agronomic traits and positive direct and indirect effects of some agronomic traits toward oil content were also obtained, this research findings will assist in making useful recommendation for the development of high oil Maize.

6.2: Conclusion

Variation obtained between the locations on the oil content is attributed to location differences based on this Samaru is the better location for developing high oil maize, because higher performance values on oil content were obtained at Samaru location, High narrow sense heritability estimates on oil content showed that significant genetic improvement could be achieve especially through mass selection and recurrent selection programmes. Negative heterosis on oil content indicated lower performance of progenies compared to their parent from varietals crosses and the alleles are not contributing positively in these varieties crosses. Correlation studies at Kadawa location indicated that selecting number of kernel rows could improve oil content because of significant genotypic and phenotypic correlations between oil content with number of kernel rows. For the combined locations it showed that selection of

grain yield per hectare could not give a positive result because of insignificant phenotypic and significant genotypic correlation between oil content with grain yield per hectare.

Path analysis results at Samaru showed that plant height recorded the highest positive direct effect toward oil content, direct selection of plant height should there fore be considered because of positive significant genotypic correlations between oil content with plant height, also indirect selection of plant height through 100 grain and ear length and 100 grain weight through number of leaves per plant could be effective in influencing oil content. Results from Kadawa location showed that ear height recorded the highest positive direct effect to oil content then followed by number of kernels per row and 100 grain weight. Direct selection of number of kernels per row should therefore be considered, because of positive genotypic correlations between oil content with number of kernels per row, but direct selection of 100 grain weight and ear height will not give a positive result because of negative genotypic correlations between oil content with 100 grain weight and ear height. Results from across locations indicated direct selection of grain yield per hectare could give a positive result because of positive genotypic correlation between oil content with grain yield per hectare, indirect selection of ear length, number of leaves per plant and grain yield per hectare through 100 grain yield should also be considered.

6.3: Recommendations

Samaru location is recommended the best for high oil maize production. For heterosis it is recommended to use high and low oil inbred lines in making crosses instead of varietal crosses, because heterosis is easily observed from inbred lines crosses. From correlation it is recommended to select number of kernel rows at Kadawa location because of presence of genotypic and phenotypic correlations. From path analysis result at Samaru direct selection of

plant height to oil content should be recommended, at Kadawa direct selection of number of kernels per row should be recommended while for across location direct selection of grain yield per hectare should be recommended.

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The result for analysis of variance at Samaru showed significant difference for all the traits except number of kernel rows, percent oil and 100 grain weight, at Kadawa all the traits indicated significant difference except percent oil and 100 rain weight, while for the combined location all the traits except 100 grain weight indicated significant difference. Genotypic and phenotypic coefficient of variation at Samaru indicated phenotypic coefficient of variation had greater values than genotypic coefficient of variation, but at Kadawa number of kernels per row had greater genotypic coefficient of variation while the rest of the traits had greater phenotypic coefficient of variation, for the combined locations, phenotypic coefficient of variation had greater values than genotypic coefficient of variation. Broad sense heritability estimates at Samaru showed high and positive estimates except percent oil and 100 grain weight that showed negative estimates, at Kadawa all the traits indicated positive broad sense heritability estimates except number of kernel rows that showed negative estimates and low positive estimate for oil content, for combined locations all the traits indicated high and positive estimates. From analysis of variance in both and combined location additive gene actions appeared to be more important than dominance gene action in the control of percent oil. Narrow sense heritability estimates is positive and high for both locations while for the across locations the estimates is positive and low for oil content. Heterosis for oil content at both and the across locations were all negative. Correlation results at Samaru did not record any significant correlation between oil content with the rest of agronomic traits, while at Kadawa there were significant phenotypic and genotypic correlation between oil content and number of kernel rows, for the combined locations there was significant genotypic correlation between oil content with grain yield. Path analysis result at Samaru showed plant height had the highest direct positive effect on oil content and

indirect positive effects of plant height and number of leaves per plant through 100 grain weight and ear length. At kadawa number of kernel rows, 100 grain weight and ear height had direct positive effects on oil content and indirect effect of ear height through plant height, while for combined locations grain yield recorded positive direct contribution toward oil content.